CALIFORNIA FISH AND GAME

VOLUME 40 JANUARY, 1954 NUMBER 1

1850

Published Quarterly by the
CALIFORNIA DEPARTMENT OF FISH AND GAME
SACRAMENTO

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A NESTING STUDY AND POPULATION SURVEY OF CANADA GEESE ON THE SUSAN RIVER, LASSEN COUNTY, CALIFORNIA[1]

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INTRODUCTION

In the production of waterfowl in California the Honey Lake Valley is surpassed only by the Klamath Basin, and compares favorably with Goose Lake, Surprise Valley and the Pit River Valley. These areas are distributed over the great basin region of northeastern California, and together produce almost one-third of the waterfowl reared in the entire State.

One of the important waterfowl areas in Honey Lake Valley is the Susan River and its diversions. The river is composed of the main channel and diversion canals along the course it follows through the valley to Honey Lake. The river channel is deep and narrow; it seldom exceeds a width of more than 60 feet. The banks are bordered with intermittent stands of willow, sagebrush and greasewood, grass, or devoid of vegetation altogether.

Honey Lake Valley is located in the southeastern section of Lassen County, and is typical of the great basin sagebrush type of vegetation described by Jensen (1947). The average elevation throughout the valley is about 4,000 feet, and the climate is distinctly semiarid with an average rainfall of slightly less than 18 inches annually. However, this data is from the nearest weather station (Susanville) which receives considerably more rainfall than the remainder of the valley which lies to the east. A more nearly correct average rainfall for the valley would fall between 8 and 10 inches annually.

The early winter rains and spring runoff during wet years combine to fill Honey Lake; when this occurs a buildup in nesting density of waterfowl is evident. During these periods of high water, the marsh vegetation which is nonexistent through the drier years recovers quickly, resulting in greater abundance of nesting habitat. Honey Lake was full in 1937, and gradually became dry until 1951, when abnormal winter rains and snowfall combined to fill the lake again and, with the continuation of wet years, it has remained full since that time.

[1] Submitted for publication August, 1953. Federal Aid in Wildlife Restoration Act, Project California W30R. Cliffa E. Corson prepared the maps and figures.

FIGURE 1. Great Basin Canada Geese. The bird on the left is an immature male and on the right is an immature female. *Photograph by A. E. Naylor, August, 1952.*

The majority of resident waterfowl in the valley, including the Great Basin Canada Goose (*Branta canadensis moffitti*), nest in the agricultural area adjacent to the north shore of Honey Lake (Figure 1). The north shore of the lake (the Susan River delta) has a fair growth of marsh vegetation suitable as nesting cover. The remaining edges of the lake are bare or have a low growth of salt grass, and as a result, have little nesting activity occurring there. In addition to the agricultural area, the irrigated pastures and meadowland bordering the Susan River and the banks of the river are suitable as cover for nesting waterfowl.

A study (Naylor 1953) of nesting Canada geese on Honey Lake Refuge, located along the north shore of Honey Lake, was conducted in 1951. Throughout this report references are made to the 1951 study. However, further citations of that study will be omitted. In 1939 and 1940, Dow made a nesting study of Canada geese in the Honey Lake Valley. Since the study in 1951 was limited to the refuge, it seemed necessary to evaluate the nesting along the Susan River in order to obtain an over-all picture of the valley as a breeding area for the Canada geese.

The objectives of this study were to determine the number of Canada geese using the river and to obtain production data from goose nests found along the river as compared to the nesting on the Honey Lake Refuge. The results are given in this paper.

This study encompassed an area along the Susan River and its diversions from the town of Johnstonville to the Honey Lake Refuge, a distance of approximately 16 miles (Figure 2). Land use in this study

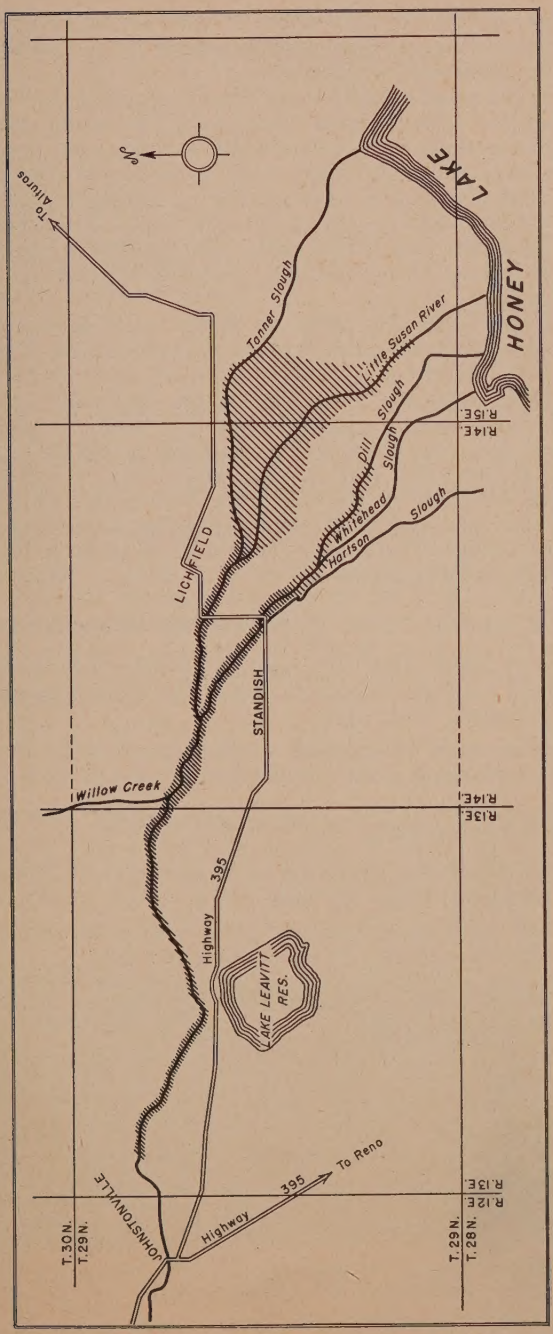

FIGURE 2. Study area along the Susan River

area was mainly devoted to agriculture of which a major portion was irrigated pasture. Little or no attempt was made by the landowners to improve nesting habitat for waterfowl.

Both sides of the river and adjoining pastures or fields were searched where the cover was suitable for nesting geese. The 16-mile study area was divided into sections. By systematically searching one section each day, two men could cover the entire study area at one-week intervals. All the nests that were found were marked to facilitate return visits; and nest history cards were compiled for each nest. All pertinent information concerning the individual nests, their contents and development was recorded on each visit. The interval between visits to all nests was seven days.

A sample of nests was also taken on Honey Lake Refuge for comparison with the production data obtained from the Susan River. Since the two areas are different in cover type, land use and management, no attempt was made to obtain a random sample, and only nest history data was completed on the refuge. It was felt that a comparison of cover types and nest sites between the two areas would be misleading.

The study was begun on April 1, 1952, and continued until the last nest history was complete on May 26, 1952. During this time nest histories were completed on 58 nests along the Susan River and 57 nests on Honey Lake Refuge. The nesting density of 58 nests in 16 miles of the river represents 3.6 nests per mile.

NEST SITES AND COVER TYPES FOR THE SUSAN RIVER

Six different types of nest sites were utilized by the nesting geese during this study. It may be well to define the classifications of nest sites in order to clarify the subject.

Marsh—Areas such as artificial ponds, sloughs, lake shores, and semiwet land constituted the marsh type of nest site.

Ditchbank—Ditchbank sites were elevated margins of any slough, river or irrigation ditch.

Island—An island was construed to be any body of land, regardless of size, surrounded by water.

Undisturbed Field—Any field not under cultivation at the time of the study was classified as an undisturbed field.

TABLE 1

Nest Sites Utilized by Canada Geese

Nest site	No. of nests	Percent
Ditchbank	28	48.3
Marsh	17	29.3
Island	8	13.8
Pasture	3	5.2
Undisturbed Field	1	1.7
Fence Row	1	1.7
Totals	58	100.0

TABLE 2

Cover Types Utilized by Canada Geese

Cover type	No. of nests	Percent
Hardstem bulrush (*Scirpus acutus*)	23	39.7
Grasses (*Gramineae*)	10	17.2
Willow (*Salix sp.*)	6	10.3
Sweet clover (*Melilotus alba*)	5	8.7
Three-square (*Scirpus paludosus*)	4	6.9
California wild rose (*Rosa californica*)	3	5.2
Five-hooked bassia (*Bassia hyssopifolia*)	3	5.2
Cockle burr (*Xanthium canadense*)	2	3.4
Marsh smartweed (*Polygonum muhlenbergii*)	2	3.4
Totals	58	100.0

Pasture—Irrigated pasture used for grazing livestock was classified as pasture land. This site could be included in the marsh type areas that are generally wet throughout the spring.

Fence Row—The nests located in the cover along any fence line.

Nest site preferences are summarized in Table 1.

Table 2 summarizes the data on the specific plants that make up each cover type. In all cases the dominant plant in the immediate vicinity of the nest was taken as cover type.

The high incidence of hardstem bulrush is due to the occurrence of this plant in the shallow sloughs and ditches that meander through some of the fields and pastures adjacent to the river (Figure 3). This type was highly sought after as nesting cover. The remainder of the cover types are more indicative of the actual cover on the islands and along the river banks. The stretches of river bordered by wet pastures

FIGURE 3. Irrigated pasture showing a slough with hardstem bulrush along edges. *Photograph by A. E. Naylor, July, 1953.*

or meadows seemed to be preferred, and larger numbers of geese used these areas for loafing, feeding or nesting. Figures 4, 5, and 6 illustrate the major types of cover found along the banks of the river.

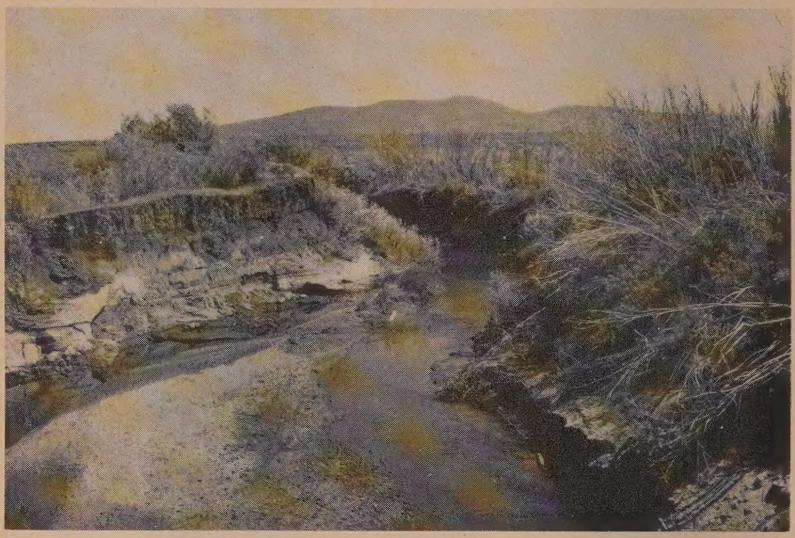

FIGURE 4. The Susan River during low water showing the banks lined by willows. Note the narrow, deep channel which is typical of this river. *Photograph by A. E. Naylor, July, 1953.*

FIGURE 5. The Susan River, showing grasses growing to the banks' edge. Very little nesting occurred in this type of cover. *Photograph by A. E. Naylor, July, 1953.*

FIGURE 6. The banks of the Susan River with sagebrush and black greasewood growing to the water. *Photograph by A. E. Naylor, July, 1953.*

NESTING PERIOD AND HATCHING DATES

The nesting season was retarded almost a month by the inclement weather conditions, and the geese were delayed in nest construction until the latter part of March.

The systematic searching for nests was begun on the Honey Lake Refuge sample April 9th and the first nest was recorded on that date. Searching for nests along the Susan River began on April 16th with the first nest being recorded on that date. It should be remembered that the nesting season was under way on those dates, and the first nests found were not necessarily the first nests on the area. The 1951 nesting season began on March 18th on Honey Lake Refuge. Dow (1943) states the nesting season was well under way on March 16, 1939, and the first nest was discovered on March 6, 1940. In 1952, at Tule Lake and Lower Klamath National Wildlife Refuges, Miller and Collins (1953) reported finding the first nest on April 5th.

Figure 7 illustrates the interval of hatching between the two study areas. It is interesting to note that 58 percent of the hatching on Honey Lake Refuge took place during the one week interval of April 27th to May 3d. Eighty-three percent of the nesting population on the Susan River completed their nests successfully between April 27th and May 10th. Nesting along the Susan River was approximately one week later than that on the refuge. The peak of the hatch in 1951 occurred during the period of April 15th to April 30th. These data indicate a later nesting season in 1952, but the latter population, after being delayed by the weather conditions, nested over a shorter period.

All nesting on the study areas ceased by May 26th, and the study was terminated on that date.

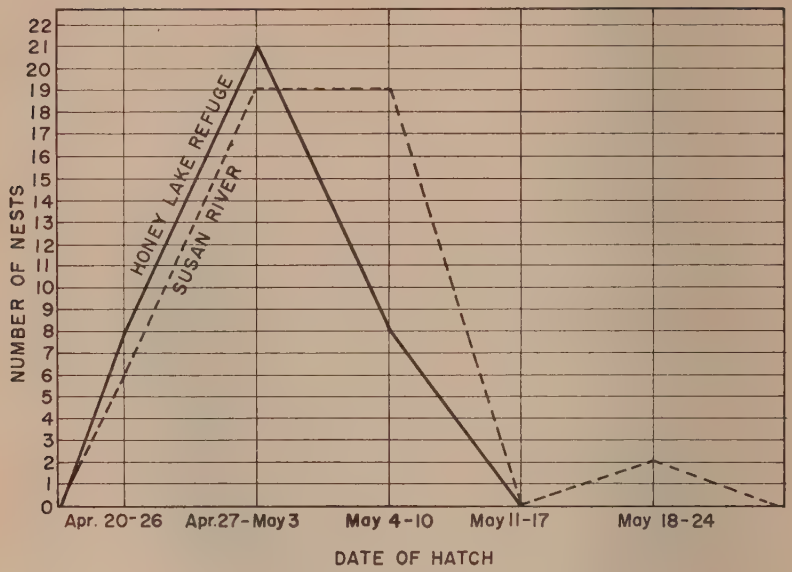

FIGURE 7. Comparison of the peak of hatch between Honey Lake Refuge and Susan River Canada goose populations

FATE OF NESTS

Some description of the fate of the nests will clarify the method of recording that data. If some or all of the eggs in the nest hatched, or if shell fragments and membranes from hatched eggs remained, the nest was recorded as hatched. Destroyed nests were classified as such when the nest showed signs of molestation by some outside factor. A nest was considered as deserted if egg-laying or incubation had ceased and no evidence could be found of the nest having been disturbed. Table 3 gives a breakdown on the fate of nests.

Only data from the successful nests were used in determining the fate of eggs and average clutch size. Of the 115 nests found in the study 83 were hatched successfully; 46, or 79.3 percent, were successful on the

TABLE 3

Fate of Nests

Fate	Susan River		Honey Lake Refuge	
	Number of nests	Percent	Number of nests	Percent
Hatched	46	79.3	37	64.9
Destroyed	7	12.1	12	21.1
Deserted	5	8.6	8	14.0
Totals	58	100.0	57	100.0

Susan River and 37, or 64.9 percent, on the refuge unit. The successful nests produced 432 eggs of which 358 were hatched—216 on the river and 142 on the refuge—giving a hatching percent of 88.9 and 75.1 percent respectively.

The Susan River sample of successful nests produced a total of 243 eggs for an average clutch size of 5.3. On the refuge, the 37 successful nests produced 189 eggs for an average clutch size of 5.1. The average clutch size in 1951 was 5.5 eggs per nest.

Any eggs remaining in the hatched nests with the yolks suspended or partially suspended in the albumen were considered as infertile eggs. All other eggs were recorded as dead embryos in the various stages of development. The difference between dead embryos and infertile eggs was determined by the method used by Kossack (1950). The 243 eggs in the river sample produced only 2, or 1 percent, infertile eggs while 7, or 3.7 percent, infertile eggs were found in 189 eggs produced in the successful nests on Honey Lake Refuge. A 2 percent infertility was recorded on Honey Lake Refuge in 1951.

The destroyed nests were grouped into the rather broad classifications of mammalian predation and unknown causes. The latter group consists of nests where no clues to the fate of the nest were ascertainable. Avian predation, while it was the most prevelant form of nest destruction in the 1951 study, was entirely absent on both study areas in 1952.

Identifying a nest predator from the remains of the nest is difficult in most cases and it was believed the broader classification used would still be significant (Table 4). Predators known to inhabit both areas are striped skunk, coyote, weasel, ring-billed gull, California gull, crow and magpie.

There were no nests lost by flooding, a fact which may have been due to the late nesting season. By the time the geese started to nest the major runoff had passed.

BROOD DATA

The first brood was recorded on April 21st, three weeks later than the first brood record in 1951, substantiating further the later nesting season in 1952. Seventy broods of the one-week-old class were recorded with a total of 289 young for an average brood size of 4.12. Brood counts were made throughout the Honey Lake Valley and the circumstances

TABLE 4

Fate of Unsuccessful Nests

Fate	Susan River		Honey Lake Refuge	
	Number of nests	Percent	Number of nests	Percent
Mammal	2	28.6	3	25.0
Unknown	4	57.1	2	16.7
Destroyed when found	1	14.3	7	58.3
Totals	7	100.0	12	100.0

TABLE 5

Brood Records

	Brood records			
	One-week old	Two-week old	Three-week old	Total broods
Number of broods	70	21	5	96
Average brood size	4.12	4.09	5.2	4.17

made it impossible to differentiate between the two areas. Table 5 presents the data on brood sizes based on a comparatively small sample of brood counts. The habit of the goose broods grouping together after the first week makes it difficult to obtain true records of older broods. Data on brood regression is masked by this habit and is thought to be unreliable.

POPULATION

One of the objectives of this study was to determine the numbers of geese using the river during the breeding season. To arrive at a population figure a ground survey was carried out during the study on the river and the adjacent fields. Two aerial surveys were made to substantiate the ground count. One survey was flown early in the study (April 6th); the ground survey covered the period from April 6th to 28th, and the second aerial flight took place on May 12th near the end of the nesting season. The figures for the Susan River portion of the 1952 California Breeding Ground Survey (Chattin, et al.) are included to further illustrate the seasonal shifts of the geese in this area. In all the surveys except the June 6th flight (Calif. Breeding Ground Survey) pairs and single birds were counted as breeding pairs, and the groups of three or more were taken to be nonbreeding geese. Only adult geese were counted, and no broods or young of the year are included in the figures for the ground survey and the first two aerial surveys. The June 6th figures represent total numbers since this flight is made annually to determine production, and the survey usually occurs after the geese have completed nesting (Table 6).

It was believed that many of the pairs counted were actually nonbreeders that had paired in their second year, but would not breed until the following year. Also, some of the geese in the groups may have been breeding pairs that were unsuccessful in nesting attempts during the current nesting period.

TABLE 6

Population Surveys of the Susan River

Type	Date	Pairs	Groups	Total geese
Aerial	4-6-52	357	458	1,172
Ground	4-16 to 4-28-52	506	314	1,326
Aerial	5-12-52	221	662	1,104
Aerial	6-6-52	----	152	152

TABLE 7

Age Ratio of Banded Geese

	1950	1951	1952	1953	Total	Percent
Adults	67	74	98	147	386	32.7
Immature	173	227	39	356	795	67.3
Totals	240	301	137	503	1,181	100.0

It is the opinion of the writers that the population of geese inhabiting the Susan River are mainly nonbreeders spending the early part of the breeding season in this area. With the advent of the post-nuptial moult, the geese seem to feel the need for more secluded areas and larger bodies of open water and emergent vegetation for escape cover during the flightless period. These areas of concentration for the Honey Lake Valley birds are believed to be Eagle Lake, Honey Lake (both in Lassen County) and Pyramid Lake just across the state line in Nevada. Breeding ground surveys for previous years indicate there is a buildup of the adult population in these areas during the latter part of the nesting season.

As further evidence of the population shift, the adult-immature ratio of Canada geese banded at Honey Lake and Honey Lake Refuge during the years of 1950 through 1953 is included in Table 7. The annual banding operation usually takes place during the first half of June and is of the drive trapping type with a corral. Immature birds of the year and adults in the flightless stage are trapped, banded and released. Sixty-seven percent of the 1,181 geese banded have been immature birds hatched the same spring as they were banded. If the 32.7 percent adults banded was indicative of the number in the area it was obvious that some adults had deserted the valley to spend the flightless period elsewhere. It is more than likely that most of the adults banded are breeding geese that remained to care for their broods, and the adults leaving the area were made up of unsuccessful breeders and nonbreeding geese.

From the combined surveys it may be concluded that 1,100 to 1,300 adult geese were occupying the river and adjacent areas for nesting, feeding, and loafing in the spring of 1952. The ground survey during the nesting season indicated a total of 506 pairs of geese on the area. The number of nests found on the Susan River was 58 representing an estimated 60 percent of the nests on the area. The comparison of these

TABLE 8

Habitat Preference of Canada Geese in Honey Lake Valley

Unit	Nesting area	Nonbreeding area
Susan River and diversions; adjacent fields	Fairly abundant	Major area
Farm land	Limited	Limited
Meadow, irrigated pasture and north shore of Honey Lake	Major area	Major
Honey Lake (other shores)	Very limited	Limited
Sagebrush and greasewood	None	None

data corroborates the assumption that the majority of the population were nonbreeders.

The breeding pairs that successfully hatched off broods along the Susan River later moved down the river to the north shore of Honey Lake where food and escape cover were more ideal.

The Honey Lake Valley was divided into five definite types according to vegetative cover, water, and land use. The value as a nesting area or an area utilized by nonbreeding geese was determined for each type. These data are presented to give an over-all picture of the valley as habitat for Canada geese (Table 8).

SUMMARY

1. A study of population and nesting Canada geese was completed on the Susan River and Honey Lake Refuge in 1952.
2. Nesting density along the 16 miles of the river was 3.6 nests per mile.
3. Preferred nesting sites were ditchbanks.
4. Nesting was delayed almost a month by weather conditions.
5. Nesting success on the Susan River was 79.3 percent successful and 64.9 percent for Honey Lake Refuge.
6. Nest destruction was the major cause of unsuccessful nests on both areas.
7. The population of the Susan River during nesting season was approximately 1,100 to 1,300.
8. It was concluded that the Susan River was primarily a nonbreeding area and secondarily a nesting area.

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A NESTING STUDY OF DUCKS AND COOTS ON TULE LAKE AND LOWER KLAMATH NATIONAL WILDLIFE REFUGES[1]

A. W. MILLER and B. D. COLLINS
Game Management Branch
California Department of Fish and Game

During the spring and summer of 1952 a waterfowl nesting study was conducted at the Tule Lake and Lower Klamath National Wildlife Refuges by the California Department of Fish and Game. A total of 826 duck nests and 154 coot nests were located on 11 sample areas comprising 1821 acres. The average nesting success of all ducks was 83.4 percent while that of coot was 94.6 percent. Desertion, flooding, and predation were the causes of nest failures in that order of importance. A review of 3814 brood counts indicated that the major reductions in brood size occurred during the first week of life.

INTRODUCTION

Tule Lake and Lower Klamath Refuges are located in the California portion of the Klamath Basin, northeastern Siskiyou and northwestern Modoc counties, at an elevation slightly more than 4,000 feet. These refuges are key points in the Pacific Flyway (Gabrielson, 1943, p. 183) providing resting and feeding areas for several million migrating waterfowl each year. They are also important as nesting areas for waterfowl in California.

During 1952, Lower Klamath Refuge, encompassing about 21,000 acres, was still in the process of being developed into excellent waterfowl habitat. The refuge consisted of four developed units with impoundments of open water interspersed with islands and patches of emergent vegetation. Five additional units were in the process of development, while another unit was under cultivation. Tule Lake Refuge totaling about 32,000 acres, is comprised of approximately 13,000 acres of water area maintained in two restricted sumps (Upper and Lower Sump) and 19,000 acres devoted to agriculture. The water depths of the sumps averaged two to three feet and about one-fourth of the Upper Sump supported a dense stand of hardstem bulrush (*Scirpus acutus*) and cattail (*Typha latifolia*).

PURPOSE

This study was motivated by the need for basic data pertaining to waterfowl production in this important area. Also, the need for data relating to the fundamental needs and preferences of nesting ducks

[1] Submitted for publication September, 1953. Federal Aid in Wildlife Restoration Act, Project California W30-R.

and coots was recognized. Such information would be useful in the formation of future management programs in this area. A similar study on Canada Geese was carried on in conjunction with this survey. The results of that study have already been published (Miller & Collins, 1953).

ACKNOWLEDGMENTS

Personnel of the California Department of Fish and Game who participated in the collection of field data were William Anderson, E. G. Hunt, A. E. Naylor, J. R. LeDonne, Robert Weld, Philip Arend and the authors. Frank M. Kozlik assisted with the preparation of the manuscript and Cliffa E. Corson prepared the maps and figures. The refuge management cooperated in many ways especially by the loan of the Fish and Wildlife Service airboat. Also, most of the brood counts were taken by Paul E. Steel, Refuge Biologist, and Victor Oglesby (now with the Nevada Game Department).

PROCEDURE

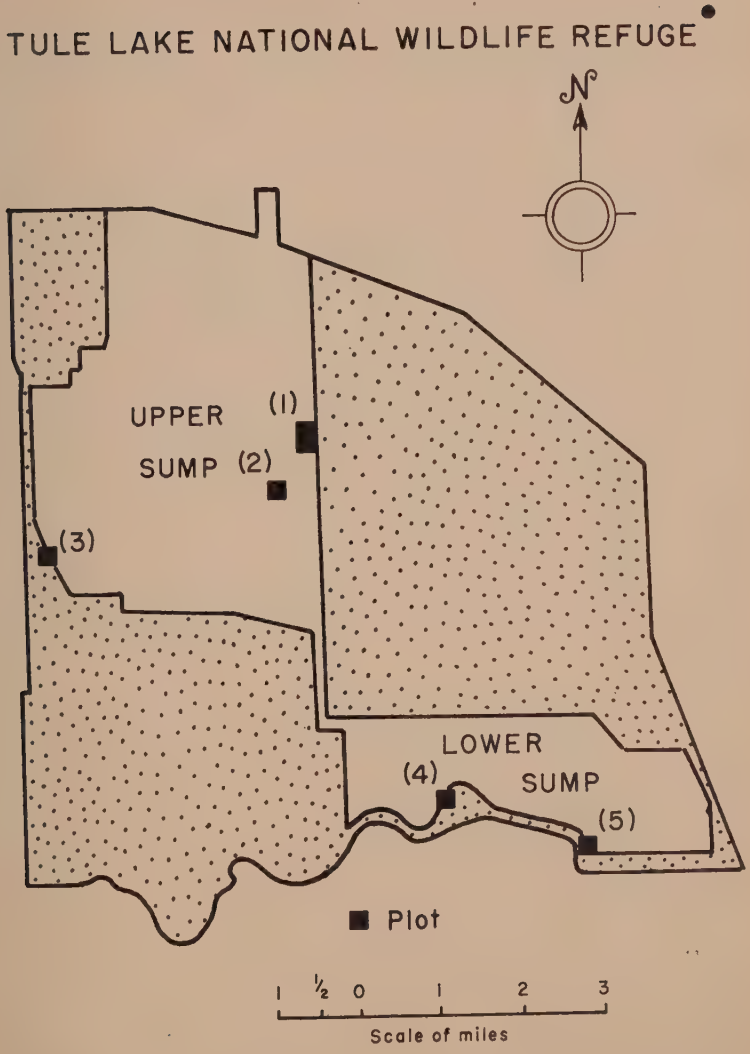
Selection of Sample Plots

The choosing of workable sample areas for the study was necessitated by the size of the refuges and the extent of the breeding population. Sample plots were established in the refuge units where major nesting occurred. The size and number of the plots depended upon the extent of the unit, the nature of the terrain, the cover types involved, and the accessibility of desirable areas. The sample areas had to be large enough to be representative, yet limited in size and number so that all areas could be searched often and thoroughly enough to obtain complete and accurate information. The use of the U. S. Fish and Wildlife Service airboat facilitated the inclusion of plots that would have been difficult and time consuming to reach and search by other means.

LOCATION AND DESCRIPTION OF PLOTS SELECTED

Five plots were selected on Tule Lake Refuge, three in the Upper Sump and two in the Lower Sump (Figure 1). Plot number one, located in the extensive hardstem bulrush growth in the northeast corner of the Upper Sump, comprised approximately 120 acres. The area was selected as typical of the dense stands of emergents, which was interspersed with channels and potholes of open water formed mainly by the activities of muskrats. The second plot, about 10 acres, on the Upper Sump was selected to represent nesting in areas of sparse bulrush stands. The third sample, 12 acres, was located along the shore-line in the southwest corner of the Upper Sump and was characterized by a band of vegetation ranging from 20 to 100 yards in width, bordered by open water on one side and high ground on the other. The vegetation was composed of hardstem bulrush, river bulrush (*Scirpus fluviatilis*), cattail, nettle (*Urtica californica*), mustard (*Sisymbrium* sp. and *Brassica* sp.), saltbush (*Atriplex* sp.) and some grasses.

The two plots located on the Lower Sump were along the south shore, Plot 4, about six acres and Plot 5, about three acres. These two plots were of the same general aspect in relation to cover as Plot 3 on the Upper Sump (Figure 1).



This map does not show differentiation between open water and areas of emergent vegetation

FIGURE 1. Map of Tule Lake National Wildlife Refuge, Siskiyou County, California, showing location of study plots

The remaining study areas were located on Lower Klamath Refuge in the units where major nesting occurred (Figure 2). Plot 6 was located in the northeast corner of Unit Two and contained some 400 acres. Natural islands ranging from less than one to several acres characterized the sample. The cover consisted mainly of patches of nettle, saltbush, mustard, foxtail barley grass (*Hordeum jubatum*), rushes (*Juncus* sp.), alkali bulrush (*Scirpus paludosus*), river bulrush and hardstem bulrush.

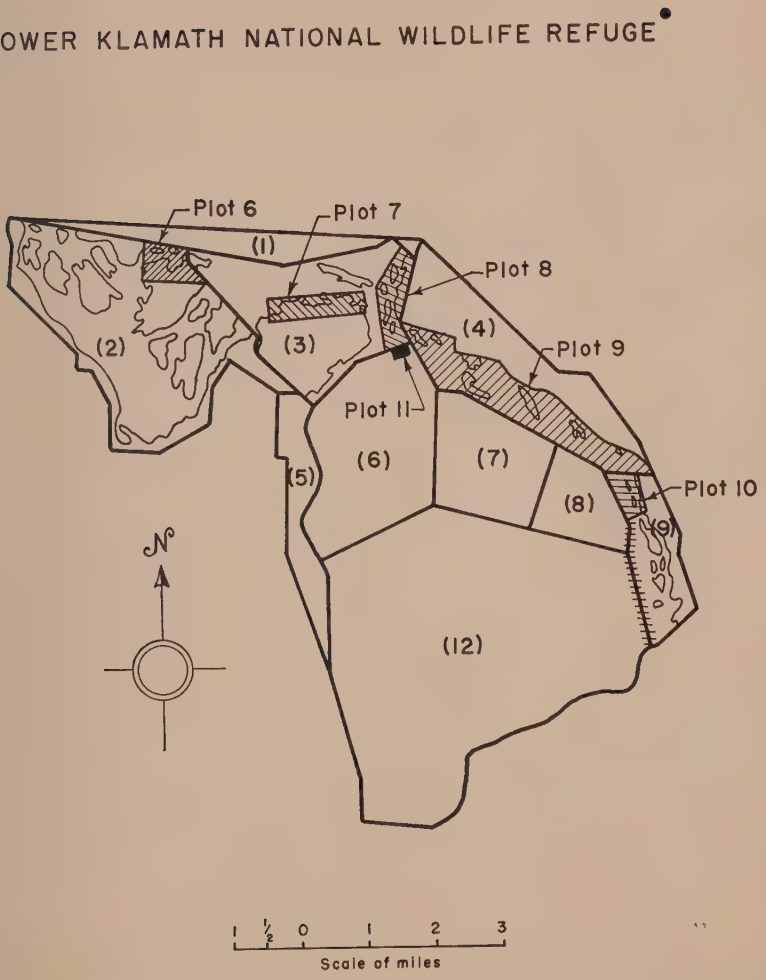
Plots 7 and 8 were both located in Unit Three. Plot 7 contained about 70 acres, and was typified by dense stands of hardstem bulrush, bordering open water, while on higher ground there were patches of nettle and saltbush interspersed with foxtail barley grass and rabbitfoot grass (*Polypogon monspeliensis*). Plot 8 consisted of the dike bordering Unit Three on the east side and islands adjacent to it. The cover on the islands varied from dense stands of cattail and bulrush, on the fringes, to heavy stands of nettle surrounding patches of mustard, saltbush and grasses in the center. The cover along the dike consisted of a band of nettle along the slopes with saltbush and mustard along the crest. The total acreage of the plot including open water areas was approximately 120 acres.

Islands, peninsulas and dikes in the flooded portion of Unit Four constituted Plot 9. The acreage of the plot consisted of some 800 acres of flooded area, but only a small fraction of that was actually nesting habitat. The estimated acreage of actual nesting habitat was 100 acres. The land cover was primarily nettle and saltbush with some grasses and mustard present. In some places, bulrush and cattail growths fringed the land areas.

The north half of the flooded portion of Unit Nine and the dike separating it from Units Eight and Twelve made up Plot 10, an estimated 240 acres. The only nesting vegetation on the dike was along the slope away from Unit Nine. Heavy stands of saltbush, mustard, five hooked bassia (*Bassia hyssopifolia*), and some scattered patches of nettle and Russian thistle (*Salsola kali*) comprised dike cover. The sample in Unit Nine was composed of areas of open water bordered and interspersed with stands of cattail and bulrush, and islands supporting stands of nettle, saltbush, five hooked bassia and foxtail barley grass.

One plot, Plot 11, was established in Unit Six to represent nests occuring in units of the refuge as yet undeveloped but adjacent to those having been developed. About 40 acres were included in the sample, the vegetation being made up primarily of foxtail barley grass and patches of saltbush. The total area included in the 11 plots was 1821 acres.

This type of sampling did not necessarily lend itself to accuracy in determining over-all nesting density or species composition, but was general enough to be representative of the nesting conditions found on the refuges. The selection, location and visitation of a large enough number of small random plots to insure a representative sample of the area, would have been too difficult and time consuming to be practical.



• This map does not show differentiation between open water and areas of emergent vegetation

FIGURE 2. Map of Lower Klamath National Wildlife Refuge, Siskiyou County, California, showing location of study plots

LOCATION OF NESTS

Nests were located on sample areas by systematic search, either covering the entire area on foot, using a drag-rope wherever feasible, or by cruising the plot with the airboat. Each nest found was assigned a number and the data recorded on a prepared nest card bearing the same number (Miller and Collins, 1953, p. 388). To aid in relocation and identification, each nest was marked with a willow stake. The stakes were placed two or three yards from the nest and in line with some chosen landmark common to all nests of the area. Each marker was numbered to correspond with the number assigned to the nest. After the initial location, each nest was visited at intervals of about 10 days.

OBSERVATION OF BROODS

Some brood counts were made in conjunction with the regular field work, but most of the observations were made by the same observer at weekly intervals along established transect courses. The age of each brood was estimated to the nearest week and grouped in weekly age classes. The criteria used in determining the age of the broods was quite similar to that described by Blankenship et al. (1953, p. 6). Our one week old class corresponded to their Class Ia, "Bright ball of fluff"; the two week old class equal to Ib, "Fading ball of fluff"; three weeks the same as Ic, "Gawky-downy"; four weeks equal to IIa, "First feathers"; five weeks equal to IIb, "Mostly feathered"; six weeks equal to IIIa, "Feathered-flightless; and the seven, eight and nine week classes the equivalent of IIIb. In the case of the seven, eight and nine week old classes the relative size of the ducklings and their ability or lack of ability to fly was used as a criterion of age. Southwick (1953) describes a similar system of classifying broods but recommends only five categories.

TABLE 1

Sample Size as Compared to Breeding Populations

	Estimated nesting population (pairs)*	Number of nests in sample	Percent of nesting population in sample
Mallard (*Anas platyrhynchos*)	2,150	209	9.7
Gadwall (*Anas strepera*)	3,100	381	12.3
Pintail (*Anas acuta tzitzihoa*)	400	44	11.0
C. Teal (*Anas cyanoptera*)	1,500	40	2.7
Shoveller (*Spatula clypeata*)	800	39	4.9
Redhead (*Athya americana*)	3,000	60	2.0
Ruddy duck (*Oxyura jamaicensis rubida*)	1,500	25	1.7
L. Scaup (*Athya affinis*)	150	10	6.7
Total ducks	12,685	808	6.4
Coot (*Fulica americana*)	4,000	149	3.7

* Figures taken from estimates submitted by Paul Steel, U. S. Fish and Wildlife Service for the Preliminary Breeding Ground Survey Report for California, Pacific Flyway Report No. 19, August, 1952.

DATA COLLECTED

The first duck nest (mallard) was located and recorded on April 17, 1952, only 14 days after the first goose nest was recorded during the same season. Duck nesting continued until about September 1st when the last of the newly hatched ruddy duck broods were noted. The duck nesting period on Tule Lake and Lower Klamath lasted approximately 150 days. A total of 23 nests were lost during the course of the study and were not used in the compilation of data to follow: The occurence of the lost nests were as follows: Plot 1, five mallard, four redhead, one cinnamon teal, four ruddy and three coot; Plot 3, one coot; Plot 4, one mallard; Plot 6, one gadwall, one coot; Plot 8, two gadwall.

In table 1 the size of the sample of each species is compared with the estimated total breeding population in the area during the same season. The table shows the relatively small samples taken for some species. In the case of the redhead and ruddy duck, the principal cause for the small sample was the difficulty involved in searching the areas in which they nested. Plot No. 1 comprising only 120 acres, where most of the ruddy duck and redhead nesting was found, required approximately one-third of the total time used to search all of the plots. The small samples of cinnamon teal and shoveller were thought to be due primarily to their particular preference for upland sites with low, rather dense cover. Cultivated barley fields provided such sites but since no agricultural land was included in this study no corroborating data is presented here. Gadwall and pintail nested on relatively high ground and their nests were fairly easy to locate.

FATE OF NESTS

Five categories, with definite limitations governing the recording of each, were outlined for classifying fates of nests as follows: (1) hatched nests, (2) deserted nests, (3) flooded nests, (4) destroyed nests and (5) fate unknown. These categories have been defined in a previous article (Miller and Collins, 1953, p. 391).

SUCCESSFUL NESTS

The nesting success for the duck nests in the sample was 83.4 percent with 674 of the 808 complete nest histories having hatched. Of the 149 completed coot nest histories, 141 hatched resulting in a nesting success of 94.6 percent, a higher rate of success than any single species of duck. Pintail, gadwall, lesser scaup and shoveller were most successful of the ducks with success rates of 93.2 percent, 90.3 percent, 90.0 percent and 89.7 percent respectively. Mallard and cinnamon teal were moderately successful with 85.2 percent and 80.0 percent, respectively. The least successful nesters in the sample were redhead with 45 percent success and ruddy duck hatching only 32 percent (Table 2).

TABLE 2

Fate of Nests

Species	Percent nests hatched	Percent nests destroyed	Percent nests flooded	Percent nests deserted	Totals
Mallard	85.2	3.7	3.4	7.7	100.0
Gadwall	90.3	3.4	0.0	6.3	100.0
Pintail	93.2	4.5	0.0	2.3	100.0
C. Teal	80.0	2.5	7.5	10.0	100.0
Shoveller	89.7	2.6	0.0	7.7	100.0
Redhead	45.0	1.7	38.3	15.0	100.0
Ruddy duck	32.0	4.0	40.0	24.0	100.0
L. Scaup	90.0	10.0	0.0	0.0	100.0
Total ducks	83.4	3.5	5.3	7.8	100.0
Coot	94.6	1.3	3.4	0.7	100.0

UNSUCCESSFUL NESTS

Flooding

The high incidence of unsuccessful nests of the ruddy duck and redhead, and to a lesser degree, the cinnamon teal, was due primarily to the flooding of nests on Plot 1, which was caused by the changing of water levels on Tule Lake. The nests built on this plot during the early part of the nesting season were in lodged clumps of bulrush from the previous year's growth. Thus, when water levels rose during the middle of May some of the nests were flooded (Figure 3). Nests built during the latter part of June and early July were constructed on top of the

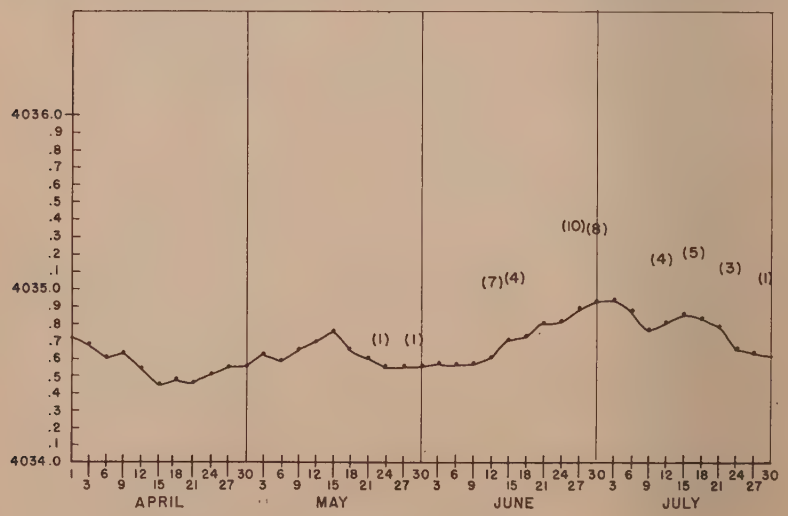


FIGURE 3. Water Levels Chart—Tule Lake, 1952 *

* Figures supplied by the Tule Lake National Wildlife Refuge.

old, lodged bulrush with the new growth of bulrush as concealing cover. As a rule, these nests were higher above the water than those built earlier. However, even these higher nests were subjected to some flooding. Actually, the period of high water, June 15th to July 15th, accounted for the greatest number of flooded nests, because the volume of nesting had increased as the season progressed. Another factor to be considered in the flooding of nests was the settling of nests built without adequate support. It was probable that in some cases the nests of either ruddy duck or redhead with a full clutch of eggs plus the incubating bird was sufficiently heavy to cause the nests to settle enough to be flooded. Nests built close to the level of the water were especially susceptible. The effect of wind on both the water levels and settling of nests was regarded as an important factor. The water level in the vicinity of Plot 1 was raised occasionally by the effect of strong winds from the southwest causing water to "pileup" in the northeast corner of the sump. The whipping of the bulrush stalks by the wind probably also accelerated the settling of the nests.

Figure 3 is a chart of the recorded water levels on Tule Lake during the nesting season. The numbers in parenthesis indicate the date and the number of nests found flooded. Some of the nests recorded as flooded June 12th and 13th were probably flooded during the high water in May but were not relocated after the initial recording until two or three visits later. The same relationship to high water applied to nests recorded flooded during other periods. The inability to relocate all nests during every visit was due to the difficulty of searching the type of cover found on plot 1.

Desertion

Only 1 coot nest, or 0.7 percent of the total, was deserted while 63, or 7.8 percent, of the duck nests were deserted. Twenty-one of the total duck nest desertions occurred on Plot 1 and involved mainly the ruddy duck, redhead and cinnamon teal. The principal cause of desertion by ruddy duck and redhead was thought to be intraspecific parasitism which resulted in "dump nests" (four redhead and three ruddy duck). Interspecific parasitism involving a ruddy duck apparently caused one cinnamon teal to desert its nest. The activity of muskrats was also recognized as a possible cause of desertion. In one instance a young muskrat (still blind) was found in a redhead nest. The low incidence of desertion on other plots involving dabbling ducks for the most part was considered of little importance. The desertion that did take place, however, was considered due partly to adverse weather conditions. High winds with rain and snow occurred during the first and second weeks of May and the second and third weeks of June.

Destruction

The rate of nest destruction by predators on Tule Lake and Lower Klamath Refuges was not high enough to greatly influence nesting success. The predator involved in nest destruction was not known in all instances. Seven nests were definitely thought to have been destroyed by coyote; six of these nests occurred on Plot 4 (42.9 percent of the nests on that plot). The remaining coyote destruction was on Plot 6 with the nest indirectly destroyed by the killing of the nesting hen. In

eight other cases of nest destruction by mammals, the specific animal was not definitely established, but the probable predators involved were: skunk in five instances; coyote in two; weasel in one. The primary avian predator in the area was considered to be the gull with large populations of both the ringbilled and California gulls present. Some ravens and magpies were in the region, but were seldom seen in the marshes where nesting occurred. One of the five nests destroyed by birds was accomplished by the killing of a nesting ruddy duck by a hawk or owl. Two nests were recorded as having been destroyed by snakes. In another case, the incubating hen was found dead at the nest and, for want of a better classification, the nest was recorded as destroyed. No clues were found regarding the predator involved in five additional nests recorded as destroyed. In all, 20 nests were destroyed accounting for 3.5 percent of the total nests in the sample as shown in Table 2.

FATE OF EGGS AND CLUTCH SIZE OF SUCCESSFUL NESTS

To determine fate of eggs and average clutch for each species, only the data from successful nests were used to avoid possible distortion of figures. To include egg data from all nests would have required hypothetical criteria to have been set up to determine for the unsuccessful nests the probable number of eggs that should have hatched, resulted in dead embryos, or have been infertile. Where some eggs were destroyed or missing, an examination could not be made to determine probable outcome. Nests that were hatched when found were also excluded from the determination of the fate of eggs or average clutch, because the number of eggs in the original clutches could not be accurately determined.

The eggs resulting from interspecific parasitism and parasitism by pheasants are indicated in parenthesis in the total eggs column of Table 3 for each species affected. The figures in parenthesis in the average clutch column show average clutch after eggs resulting from known parasitism were subtracted from the total eggs of each species

TABLE 3

Clutch Size *

Species	Successful nests	Total eggs	Average clutch
Mallard	178	1622 (44)	9.2 (8.9)
Gadwall	344	3834 (38)	11.1 (11.0)
Pintail	41	376	9.2
C. teal	32	343 (16)	10.7 (10.2)
Shoveller	35	389 (14)	11.1 (10.7)
Redhead	†27	303	13.8
Ruddy duck	8	64	8.0
L. scaup	9	96	10.7
All ducks	674	7027 (112)	10.5 (10.3)
Coot	‡141	1114	7.9

* Figures in parenthesis indicate the known number of eggs occurring as a result of nest parasitism and the resulting clutch size with those eggs subtracted from the totals.

† Five nests hatched when found not included in computation for total eggs or average clutch.

‡ One nest hatched when found not included in computation for total eggs or average clutch.

involved. These figures were compiled for the sake of accuracy and additional information, although the definition of clutch is regarded as including all the eggs incubated by the nesting bird.

The total eggs resulting from parasitism in duck nests was 112 of which 72 were pheasant eggs and the remaining 40 were duck eggs from species other than the nesting duck. The percent of pheasant and duck eggs that were hatched in the parasitized nests was 44.6 and 17.5 percent respectively. Intraspecific parasitism of duck nests was, of course, not apparent except where the effect of the parasitism resulted in "dump nests" (four redhead and three ruddy duck). Some intraspecific parasitism was thought to have taken place in successful redhead and ruddy duck nests and may have contributed to slightly higher average clutch for those species than would normally occur. The high rate of dead embryos found in unhatched eggs in successful nests of those species (Table 4) further substantiates that assumption, since it is likely that fertile eggs deposited in a nest after incubation had begun would not hatch with the original clutch but would result in partially developed embryos.

The successful duck nests produced 7,027 eggs of which 6,435 hatched resulting in an over-all hatching success of 91.6 percent. The hatching success for coot was 97.6 percent with 1,086 eggs hatched from the 1,114 eggs produced.

Unhatched eggs left in successful nests either contained dead embryos or were infertile and were classified according to Kossack's method of determination (Kossack, 1950, p. 646).

From the sample of 7,027 eggs, 376 were found to contain dead embryos and 93 were infertile (Table 4). Though a high percentage of redhead and ruddy duck eggs contained dead embryos, the total number was not great enough to have an appreciable effect upon the average for all species. The eggs that were destroyed or missing accounted for the remaining 123 eggs. These eggs were not considered to be a source of error in determination of any factor in the fates of eggs, but rather, were regarded as an index to the number of eggs from otherwise successful nests that would meet various fates during the course of a nesting

TABLE 4

Fate of Eggs

Species	Eggs					
	Percent hatched	Percent dead emb.	Percent infertile	Percent destroyed	Percent missing	Total
Mallard	91.4	4.9	1.6	0.4	1.7	100.0
Gadwall	94.2	3.3	1.1	0.3	1.1	100.0
Pintail	92.3	5.1	1.9	0.0	0.7	100.0
C. teal	88.4	9.0	0.9	0.0	1.7	100.0
Shoveller	91.5	4.4	1.3	0.0	2.8	100.0
Redhead	68.6	24.8	3.0	0.3	3.3	100.0
Ruddy duck	70.4	28.1	0.0	0.0	1.5	100.0
L. scaup	87.5	10.4	2.1	0.0	0.0	100.0
Average	91.6	5.4	1.3	0.3	1.4	100.0
Coot	97.6	1.7	0.2	0.4	0.2	100.0

TABLE 5

Brood Counts *

Species	Average hatch per clutch	1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks	9 weeks	Total broods
Mallard	8.3	(227) 6.8	(158) 7.0	(122) 6.3	(83) 6.5	(56) 7.6	(39) 6.6	(58) 7.8	(87) 7.8	(30) 6.2	(860)
Gadwall	10.5	(326) 6.8	(227) 6.5	(149) 6.6	(101) 6.4	(57) 6.5	(70) 6.6	(84) 6.5	(49) 6.9	(1) 5.0	(1064)
Pintail	8.5	(11) 6.5	(16) 7.5	(6) 5.0	(8) 5.0	(6) 6.3	(4) 6.5	(9) 4.8	(14) 6.0	(6) 5.3	(80)
C. teal	9.5	(26) 6.6	(12) 6.1	(5) 4.4	(3) 6.3	(4) 9.5	(2) 5.5	(9) 7.8	(8) 6.9	(2) 4.5	(71)
Shoveller	10.2	(74) 7.3	(28) 6.1	(20) 6.2	(8) 5.9	(11) 4.9	(6) 7.5	(4) 7.5	(6) 7.7	(1) 5.0	(158)
Redhead	9.5	(295) 6.8	(243) 5.7	(139) 6.0	(64) 5.4	(48) 6.0	(40) 7.2	(54) 7.3	(28) 6.4	(2) 7.5	(913)
Ruddy duck	5.6	(115) 5.2	(100) 5.5	(47) 5.1	(28) 4.4	(14) 5.6	(7) 4.0	(8) 4.3	--	--	(319)
L. scaup	9.3	(44) 7.3	(26) 6.8	(34) 6.9	(23) 6.7	(8) 5.9	(3) 6.0	(13) 7.9	(4) 6.5	--	(155)
Average number young per brood	--	(1118)	(810)	(522)	(318)	(204)	(171)	(239)	(196)	(42)	(3620)
Ducks	9.6	6.7	6.1	6.2	6.2	6.7	6.5	7.1	7.4	6.0	
Coot	7.8	(69) 5.2	(68) 5.3	(32) 5.4	(12) 4.3	(7) 5.3	(5) 5.2	(1) 6.0	--	--	(194)

* The numbers in parentheses indicate the number of brood counts in each sample.

season in this area. It is quite likely, however, that they would have hatched, contained dead embryos, or have been infertile in the same ratios as shown in Table 4.

Table 4 does not show separate data for parasitized nests. The presentation of those data was considered unnecessary since no important changes would be apparent in any category. Also, since no definite determination could be made concerning intraspecific parasitism, the figures would not be consistent.

BROOD DATA

Table 5 shows the average number of individuals hatched from the nests of each species of waterfowl whose nests were studied, compared to the average number of young per brood remaining during each successive week of life up to nine weeks.

The highest mortality rate in the young ducks produced on the refuges took place during the first week of life with 30 percent reduction in the average brood size hatched from nests in the sample. The average brood size resulting from hatching success of all species in the sample was 9.6 individuals. The average brood size for all species of ducks aged one week or less, as computed from 1,118 brood counts taken on the refuges, was 6.7. The average number of young hatched from the coot nests studied was 7.8 and the average brood size at the end of the first week was 5.2, a reduction of 33 percent. The apparent reduction in brood sizes during the first week of life in all species listed as compared to the average hatch per clutch in column one, Table 5, cannot be definitely accounted for. But, considering that natural mortality rates should be inversely proportional to the age of the young, a reduction in brood size during the first week would not be uncommon. In species that show high first-week mortality, especially gadwall with a 35 percent reduction, it was suspected that gull predation on downy young was partially responsible. Where average brood sizes remained relatively stable from the second week on, either the brood regression was masked by grouping together of broods causing higher counts for brood size, or that natural mortality and predation became insignificant. However, it is unlikely that grouping had an enlarging effect upon broods in the same proportion that mortality reduced the average brood size, thereby producing the stable brood sizes indicated in Table 5. Since the grouping together of broods was recognized as a possible source of error in determining average brood sizes in different age classes, only those broods that seemed free of grouping were counted. Since most of the grouping occurs in the older broods, the practice of not counting groups of broods is evidenced by the lower number of counts recorded for the older brood classes. Thus, for these reasons, it was thought that mortality factors did not greatly reduce brood sizes after the first week. Other evidence to support this conclusion is that predation on broods by gulls seemed limited almost exclusively to the downy young. Other predators that might have seriously affected brood sizes were practically nonexistent in this area. Weasels, though common in the area, are not aquatic and the mink is rare. Disease did not seem to be a factor in brood reduction.

DATE OF HATCH

The actual hatching dates of nests could not be ascertained except when the nest was found hatching during a visit. The hatching dates, grouped into 10-day periods, were approximated from the visiting dates and the accumulated data gathered during the various visits to the nests. Fifteen 10-day periods running from April 3d to August 31st were required to cover the nesting season for all species. Data from hatching dates recorded are shown in Figure 4 indicating the peak of hatch for ducks and coots occurred between June 22d and July 1st. Figure 5 illustrates the relationship of the hatching dates by species for comparison with Figure 4. Figure 5 includes the dates wherein the greatest volume of hatching took place in all species. It would be expected that extremes (both early and late nesting) would be encountered in any nesting population, but not necessarily appear in the sample areas due to their limited occurrences. Some late hatched nests were indicated for the ruddy duck, as newly hatched broods were noted on the refuges as late as September 1st. However, no extremely late hatched nests were noted on the study plots.

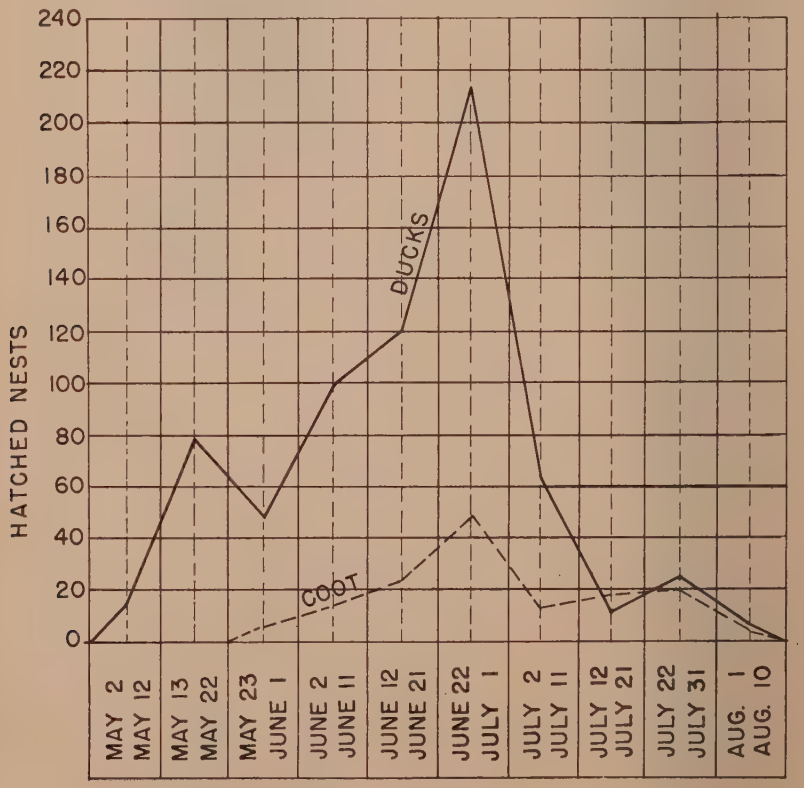


FIGURE 4. Date of hatch

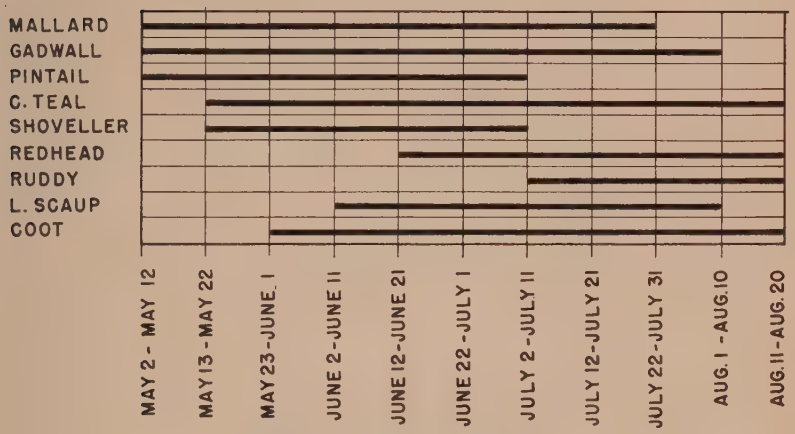


FIGURE 5. Hatching periods by species

NEST SITES AND COVER TYPES

Nest Sites

The categories used to present nest site data in Table 6 are, for the most part, self-explanatory. However, for the purpose of clarification, it may be well to define some of the classifications used. Marsh applies to nest sites that occurred over water or wet area and in most cases indicates a nest basket built in bulrush or cattail or on a pile of vegetation erected by the bird. Although the muskrat house category could be grouped with "marsh," it seemed desirable to separate the two. Upland denotes areas that were normally above the water level and had grown rank with weeds and grasses. No distinction was made between dikes, levees and ditch banks, traveled or untraveled, and they were held synonymous as nest sites. Nest sites were recorded as occurring on islands when the area of the island was less than 8 or 10 acres. Where nests occurred on larger islands (Figure 2, Plot 6) the site was considered to be in "upland" type.

TABLE 6

Location of Nest Sites

Species	Dike	Marsh	Muskrat house	Island	Upland	Total
Mallard	25.9	17.3	2.4	33.1	21.3	100.0
Gadwall	13.4	0.5	0.3	61.9	23.9	100.0
Pintail	6.7	0.0	0.0	31.8	61.4	100.0
C. teal	20.0	15.0	5.0	42.5	17.5	100.0
Shoveller	0.0	0.0	0.0	18.0	82.0	100.0
Redhead	0.0	86.6	6.7	5.0	1.7	100.0
Reddy duck	0.0	100.0	0.0	0.0	0.0	100.0
L. scaup	0.0	0.0	0.0	80.0	20.0	100.0
Total average	14.4	15.0	1.5	43.8	25.3	100.0
Coot	0.0	87.3	0.0	8.7	4.0	100.0

TABLE 7

Distance From Nest Site to Water

Species	Over water	0-3	3-50	50-100	Over 100	Total
Mallard	15.8	11.5	66.1	4.8	1.8	100.0
Gadwall	1.0	7.4	85.3	5.3	1.0	100.0
Pintail	0.0	6.8	61.4	29.5	2.3	100.0
C. teal	17.5	22.5	60.0	0.0	0.0	100.0
Shoveller	2.5	5.1	64.1	18.0	10.3	100.0
Redhead	93.3	0.0	6.7	0.0	0.0	100.0
Ruddy duck	100.0	0.0	0.0	0.0	0.0	100.0
L. scaup	0.0	20.0	80.0	0.0	0.0	100.0
Average (ducks)	15.6	8.4	68.2	6.2	1.6	100.0
Coot	85.9	8.7	4.7	0.7	0.0	100.0

The location of nests in relation to water was recorded for all species. Five categories were used: over water, 0 to 3 yards from water, 3 to 50 yards from water, 50 to 100 yards, and over 100 yards. The conditions in relation to water existing at the time the nest was located were recorded and that information was used to compile Table 7.

Cover Type

Only the dominant species of the plant community occurring at each nest site was recorded. The physical characteristics of that dominant plant served to illustrate the type of cover present at the nest (Table 8). During the early part of the duck nesting only the dead vegetation of the previous year was available to the birds as cover. Early in May, the nettle patches began to grow high enough to be utilized as nest cover with other cover types following throughout May and the early part of June. The hardstem bulrush had begun to show by May 1st, growing continuously until about the first of July and reached heights up to 10 feet.

The characteristics of cover utilized by ducks and coots is illustrated in Tables 9 and 10 showing the height of vegetation surrounding the nest and the degree of concealment preferred. The information used to compile the tables was from data recorded upon the initial location of the nest and therefore more nearly represents the conditions existing at the time the nest was established. The vegetation height above the ground or water level was estimated and grouped into one of four classifications: 0 to 12 inches, 13 to 24 inches, 25 to 36 inches, and over 36 inches (Table 10). The degree of concealment afforded the nest by the cover was assigned numbers to simplify the recording of data. Numbers one through four indicate the number of sides of the nest concealed, i.e., 1, cover on one side; 2, cover on two sides; etc. The number 5 indicates cover over the nest affording concealment from above as well as on all sides while the classifications 1-5, 2-5, 3-5, denote cover over the nest and with one, two, or three sides of the nest concealed.

TABLE 8

Cover Types Utilized *

Species	Saltbush (3.7)	Mustard (5.4)	Nettle (18.4)	Bassia (0.7)	Typha (5.9)	River bulrush (0.5)	Hardstem bulrush (26.0)	Grass (38.6)	Other (0.8)	Total
Mallard	26.3	8.6	35.0	0.5	1.0	1.9	18.6	1.4	6.7	100.0
Gadwall	7.6	7.8	79.9	0.5	0.0	0.0	1.1	0.5	2.6	100.0
Pintail	15.9	29.5	27.3	2.3	0.0	0.0	0.0	9.1	15.8	100.0
C. teal	7.5	17.5	42.5	0.0	0.0	2.5	22.5	5.0	2.5	100.0
Shoveller	2.5	18.0	10.3	0.0	0.0	0.0	0.0	56.4	12.8	100.0
Redhead	0.0	0.0	1.7	0.0	5.0	0.0	91.6	0.0	1.7	100.0
Ruddy duck	0.0	0.0	0.0	0.0	0.0	4.0	96.0	0.0	0.0	100.0
L. scaup	10.0	0.0	40.0	0.0	0.0	0.0	0.0	50.0	0.0	100.0
Average ducks	11.9	9.3	51.4	0.5	0.6	0.7	16.2	4.7	4.7	100.0
Coot	0.7	0.0	3.4	0.0	10.7	5.4	69.7	5.4	4.7	100.0

* The percentage that each cover type made up of the total cover on all plots is given in parentheses under the heading of each column.

TABLE 9

Vegetative Height

Species	0″ to 12″	13″ to 24″	25″ to 36″	Over 36″	Total
Mallard	32.5	49.3	13.4	4.8	100.0
Gadwall	8.7	39.4	43.5	8.4	100.0
Pintail	68.2	25.0	6.8	0.0	100.0
C. teal	42.5	32.5	12.5	12.5	100.0
Shoveller	82.1	15.4	0.0	2.5	100.0
Redhead	6.7	8.3	16.7	68.3	100.0
Ruddy duck	0.0	4.0	4.0	92.0	100.0
L. scaup	0.0	50.0	30.0	20.0	100.0
Average (ducks)	22.7	36.4	26.7	14.2	100.0
Coot	17.4	6.0	17.4	59.2	100.0

TABLE 10

Nest Concealment

Species	5	4	3	2	1	None	1-5	2-5	3-5	Total
Mallard	50.8	15.8	8.6	5.8	2.4	2.4	1.4	0.9	11.9	100.0
Gadwall	71.3	20.5	3.7	0.5	0.0	0.3	0.0	0.0	3.7	100.0
Pintail	20.2	6.8	13.7	18.3	11.4	9.2	0.0	4.5	15.9	100.0
C. teal	70.0	15.0	5.0	2.5	0.0	2.5	0.0	0.0	5.0	100.0
Shoveller	18.0	30.7	10.3	15.4	10.3	5.1	0.0	0.0	10.2	100.0
Redhead	40.0	30.0	6.7	3.3	1.7	8.3	0.0	0.0	10.0	100.0
Ruddy duck	28.0	28.0	20.0	4.0	8.0	0.0	0.0	0.0	12.0	100.0
L. scaup	40.0	30.0	10.0	0.0	0.0	10.0	0.0	0.0	10.0	100.0
Average (ducks)	56.5	19.7	6.7	4.0	2.1	2.4	0.4	0.5	7.7	100.0
Coot	15.4	16.8	17.4	18.8	12.1	14.1	0.0	5.4	0.0	100.0

SITE-COVER RELATIONSHIPS

Table 11 represents a summary of nest site-cover relationships based on information from the previous tables. The table shows the over-all conditions preferred most often by each species. The term "general" in some categories was used where no particular preference was shown by a species for any one classification, or when no definite pattern of preference was evident. In classifications where more than one item is listed, the items are listed in order of importance.

Mallard

No particular preference was shown by the mallard regarding nest site. Most of the nests, 61.3 percent, were found in cover of saltbush or nettle that afforded good concealment. Only 12 percent of the nests were considered to be poorly concealed. Mallards were found to nest over water to a greater extent than most dabblers and 27.3 percent were within three yards of water.

Gadwall

The over-all trend in gadwall nesting indicated a preference for the drier nest sites, particularly islands. Nettle 13 to 36 inches high afforded concealment cover for 79.9 percent of the nests. Nearly all the

TABLE 11

Site-cover Relationships

Species	Nest site	Cover type	Vegetation height	Concealment	Distance to water
Mallard	General	Saltbush, nettle	13-24″	5	3 to 50 yd.
Gadwall	Island	Nettle	25-36″	5	3 to 50 yd.
Pintail	Upland	Mustard nettle	0-12″	General	3 to 50 yd.
C. teal	General	Nettle (General)	0-12″	5	3 to 50 yd.
Shoveller	Upland	Grasses	0-12″	General	3 to 50 yd.
Redhead	Marsh	Hardstem bulrush	Over 36″	5, 4	Over water
Ruddy duck	Marsh	Hardstem bulrush	Over 36″	5, 4, 3	Over water
L. scaup	Island	Grasses, nettle	13-24″	5, 4	3 to 50 yd.
Average (ducks)	Island	Nettle	13-24″	5	3 to 50 yd.
Coot	Marsh	Hardstem bulrush	Over 36″	2, 3, 4, 5	Over water

nests, 95.6 percent, were well concealed. Primarily as a result of the chosen nest sites, 85.3 percent of the gadwall nests were from 3 to 50 yards from water.

Pintail

With respect to preferred nest sites, pintail were similar to gadwall in selecting dry areas, but nested principally in the upland type habitat (61.4 percent). The concealment of the nest did not seem to be important with 38.9 percent poorly concealed and 70 percent of the nests in cover less than 12 inches high. Distances greater than 50 yards from water were recorded for 31.8 percent of the pintail nests found.

Cinnamon Teal

Cinnamon teal nested in varying sites and cover but built their nests on islands using nettle cover less than 12 inches high in 42.5 percent of the recorded instances. The nests were usually well concealed with only 5 percent occuring in sparse cover affording poor concealment. Like the mallard, cinnamon teal nested in sites over water more commonly than other species of dabblers. A preference was also shown for sites in close proximity to water with 40 percent of the nests within three yards of water.

Shoveller

A definite preference was shown by shoveller for upland nest sites of low grass or similar cover. All nests were located on upland or island sites with 97.5 percent of the nests in cover less than 24 inches high. No particular pattern of desired concealment was evident but 30.8 percent of the nests were poorly concealed with 78 percent of the nests in concealment less than what was considered excellent. More nests were located over 100 yards from water than in other species, with 28.3 percent over 50 yards.

Redhead

As would be expected, nearly all redhead nests were in marsh type habitat over water (93.3 percent including muskrat house sites) with 6.7 percent found in other areas. Only 8.4 percent of the nests were

found in cover other than hardstem bulrush. The concealment afforded by bulrush was good to excellent since the height of the bulrush ranged from two feet to as high as 10 feet in 85 percent of the cases. Eighty percent of the nests were well concealed.

Ruddy Duck

Nests of the ruddy duck were found exclusively in marsh type sites over water with good concealment. Hardstem bulrush cover was used to the exclusion of other types except river bulrush which afforded cover for 4 percent of the nests. Ninety-two percent of the nests were recorded in cover over 36 inches in height.

Lesser Scaup

The lesser scaup, a diving duck, nested principally on islands with no nests recorded on other sites except upland, completely excluding marsh type. Nettle and grasses furnished cover for 90 percent of the nests, generally affording good to excellent concealment. Ten percent (one nest) was found in sites with poor concealment, but none were located in cover less than 13 inches high. Although no nests were found over water, all were within 50 yards.

Coot

A definite preference for nest sites over water was indicated by the sample of coot nests studied. Only 5.4 percent of the nests were found more than three yards from water. Little regard for concealment was apparent although 85.8 percent of the nests occurred in marsh type cover ranging in height up to 10 feet. The preferred cover, however, was primarily of a sparse nature.

Islands were most preferred as nest sites by ducks with upland, marsh, dike and muskrat house sites following in that order of preference. With the exception of the lesser scaup, diving ducks and coots used nest sites over water almost exclusively while lesser scaup and dabblers, as a group, preferred drier nesting sites. However, 92.2 percent of all nests located in the study were within 50 yards of water. Mallard and cinnamon teal exhibited the least selective preference for particular types of nesting habitat and would be the species least likely to be greatly affected by a change in availability of any one of the nest site types. Others, however, showing limited adaptability would be greatly affected by a change in available desired nesting habitat, particularly diving ducks and coots.

Desirable nesting cover for waterfowl was furnished by the extensive stands of bulrush and cattail that occurred on Tule Lake and Lower Klamath Refuges. The importance of the bulrush was greater than that of cattail because of the heavy, lodged clumps remaining from the previous year furnishing good concealment and support for nests. New growth of bulrush eventually formed a canopy over the old lodged growth adding further concealment.

Nettle was utilized as nest cover more than any other plant (51.4 percent) although it accounted for only 18 percent approximately of the total nest cover on the study plots. Nettle occurred on the favored nest sites of dabblers, particularly islands, and provided excellent cover not only as new vegetation but in lodged stands from the previous

year's growth. Other plants of medium height, as exemplified by saltbush, mustard and thistle, that are rigid when mature and persist throughout the winter, furnished good nesting cover in the early part of the nesting period. Foxtail barley grass remained over the winter in low dry clumps and was utilized extensively by shoveller and to some extent by pintail as nesting cover.

SUMMARY

1. A duck nesting study, including data on coot, was conducted during the spring and summer of 1952 on Lower Klamath and Tule Lake National Wildlife Refuges in California by the Pittman-Robertson Research Project 30-R, California Department of Fish and Game.
2. Eleven sample plots with a total area of 1,820 acres were studied, five on Tule Lake and six on Lower Klamath.
3. A total of 826 duck nests and 154 coot nests were located.
4. The nesting success of all ducks included in the sample was 83.4 percent and of coot was 94.6 percent.
5. The major cause of duck nest failures were desertion, flooding, and predation; the major cause of nesting failures in coot was flooding.
6. The hatching success in all successful duck nests was 91.6 percent, while 97.6 percent of coot eggs hatched.
7. A total of 3,837 brood counts revealed that the major reduction in broods of all species took place during the first week of life and the brood size became relatively stable thereafter.
8. The nesting period of ducks and coot lasted approximately 150 days, with the over-all peak of hatch during the period from June 22 to July 1.
9. In general, the dabblers and the lesser scaup preferred the dryer nest sites. The other diving ducks chose marshy nest sites almost exclusively as did the coot.
10. Ninety-two percent of all nests located were within 50 yards of water.
11. Nettle was the most important duck nesting cover, while hardstem bulrush was most important for coots.

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OBSERVATIONS ON THE SAURY *(COLOLABIS SAIRA)* SEEN NEAR THE CALIFORNIA COAST DURING 1950-52[1]

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INTRODUCTION

The frequency with which the saury can be observed along the coasts of California and Baja California suggests a population of incredible size. If this population is as large as it seems to be then perhaps the fishing industry is correct in considering the species a likely source of supply as yet untapped. This, together with a decline or disappearance of more readily obtained fishes, may mean the sauries now face utilization. A preliminary step in determining the extent of the resource is to establish the degree of occurrence of the species.

The saury is a slim and brilliant silver and blue fish which grows to a foot in length. The flanks shine as if they were made of burnished aluminum. Along the tail is a series of finlets, a mark of the mackerels, but the saury is a close relative of the flyingfish and halfbeak. Typically a fish of the open seas, it is frequently seen inshore during the night. The fish school at the surface both in very small groups and in gigantic shoals, which may extend at night as far as can be seen even in the ray of a searchlight.

Sauries are easy to clean, and they are delicious to eat. The fish has very thin and soft scales which are readily removed. A thin alimentary tract can be easily taken out. Fried sauries can be eaten without trouble, since the fishes are not bony. If sauries can be canned and if the natural coloring can be held, the pack would be an attractive item.

Records published before 1900 describe the saury as a rare fish off the California coast. Up to 1915 only a dozen specimens had been obtained. Great schools of fish appeared at San Clemente in 1916 and were of a species "never noticed by anyone in that region before" (Jordan, 1916). Subsequently this species was identified as the saury we know. It was further identified as the same fish well known in Japanese seas where it supports a fishery (Hubbs, 1916).

Today the saury is known on our coast from Alaska to Baja California and westward near the Hawaiian Islands (Schultz, 1940; Roedel, 1953). On the eastern Pacific coast great numbers of the saury have been reported only from the waters of California. Specimens have been

[1] Submitted for publication June, 1953.
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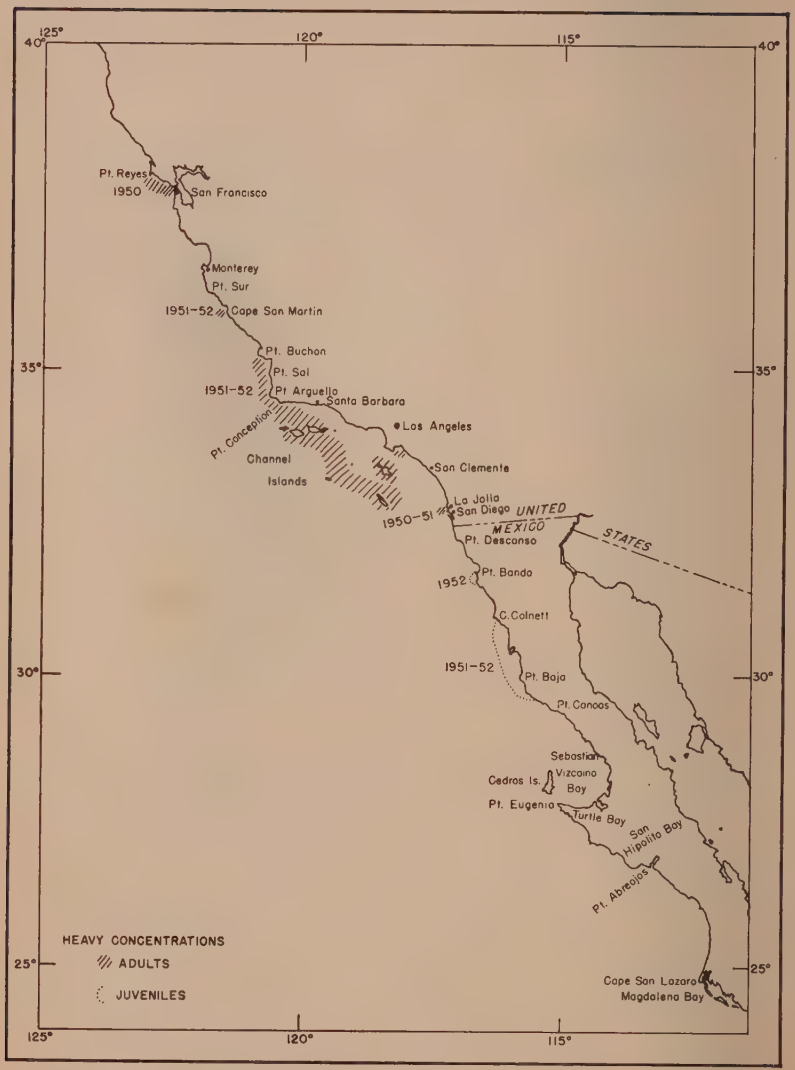

FIGURE 1. Occurrence of the saury on the California and Baja California coasts, 1950-52

taken off Cape San Lazaro (lat. 25°00′N.) in Baja California. It has been landed for the fresh fish trade at Monterey and other California ports but in such small amounts as not to have been identified in the published records. An exploratory pack was made in 1947 at Monterey. Personnel of the Marine Fisheries Branch of the Department of Fish and Game have from time to time noted unusual occurrences of the saury, but there has been no organized program to investigate the species (Aplin, 1939; Phillips, 1932).

Information which follows is drawn from field records made on the M/V YELLOWFIN by biologists engaged in the California Cooperative Oceanic Fisheries Investigation. The data refer to nighttime observations made largely within the 50 fathom curve between San Francisco and Magdalena Bay, Baja California, between October, 1950, and November, 1952 (Figure 1). Men on the research vessel were attempting to get samples of sardines (*Sardinops caerulea*) and jack mackerel (*Trachurus symmetricus*) but also kept a record of other species. Observations were made while cruising or while drifting with a brilliant light suspended over the side.

Perhaps the saury can be described as ubiquitous, for the fish was sighted in nearly every locality the ship visited. Generally there were a few present every night at one time or another, but on some occasions there were uncounted numbers in view. Characteristically, schools of sauries form a very shallow layer near the surface, and they are not often detected or recorded by a Fathometer.

OCCURRENCE

California Waters

During the fall of 1950 the YELLOWFIN operated between Point Reyes and the Channel Islands. Great schools of leaping sauries were seen in the San Francisco area (Table 1). No other fish were as abundant beside the ship, and large numbers were seen south to Point Conception. In Southern California during November they were not abundant.

TABLE 1

The Relative Abundance of the Saury (Cololabis saira) Observed on the Eastern Pacific Coast During 1950-52

	1950	1951	1952
Central California			
(Pt. Reyes to Pt. Conception)			
October	dense	moderate	--------
November	moderate	dense	moderate
December	moderate	--------	--------
Southern California			
(Pt. Conception to International Border)			
January	--------	dense	--------
February	--------	moderate	--------
March	--------	none	--------
May	--------	---- ---	none
June	--------	none	none
August	--------	moderate	--------
September	--------	poor	moderate
October	--------	--------	dense
November	moderate	dense	moderate
December	--------	dense	--------
Baja California			
(International Border to Magdalena Bay)			
March	--------	poor	poor
April	--------	poor	poor
May	--------	poor	--------
July	---- ---	--------	poor
August	--------	poor	none
September	--------	moderate	moderate

The coast of California was covered from Point Reyes to the International border in 1951 and 1952. Observations were made during 1951 from January to March, briefly in both June and August, and from late September to December. During the next year, except for a period in May and June, the cruises were made after mid-September and until November.

Peak concentrations of adult fish were seen during the winter months. These occurred in the Santa Barbara Channel region. During the spring sauries were generally not seen in the waters of Southern California. In the fall schools were seen with increasing frequency and size as the ship approached Point Conception and the offshore Channel Islands from both the northwest and southeast. Young fish were seen as far north as Point Reyes.

Baja California Waters

From March to May and during August and September of 1951, the YELLOWFIN was engaged in work along the coast of Baja California. In 1952 the same area was covered during March, April, and from July through September. Very few sauries were seen; those typically recorded were small adults or young found in small and isolated groups. Consequently, no concentrations were observed at any time in the Mexican waters that would seem to support a fishery.

Until April adults were seen alone, but after that display with young lasted for several weeks. Above Point Abreojos and along the shores of Sebastian Vizcaino Bay young fish were usually noted at every point. However, the largest numbers of young of the year and yearlings were seen in the fall and then off the steep coasts between Point Canoas and Descanso Bay.

LENGTH MEASUREMENTS

Length measurements were made of 507 sauries (Table 2). These were drawn at random from samples taken between October 1950 and November 1952. The average fork length was six inches (150 mm.) with a range of 2 to 10 inches (50 to 250 mm.). These samples represent fishes in varying stages of growth drawn in some cases from widely separated localities.

The largest average size in the samples was 10 inches. These large fishes came from the coasts along the Channel Islands of Santa Cruz and San Clemente. Eight and nine inch (203 and 228 mm.) sauries were typical in a series of samples secured from Point Sal to Point Reyes, which was as far north as the ship went. In October the average size of sauries between San Francisco and Point Conception was 6½ inches. In September sauries in Southern California were about six inches. None of the Mexican samples contained fish of a size comparable to those of the central California coast. The fish from the Mexican coast ranged from two to eight inches (50 to 203 mm.) with an average length of four inches (100 mm.). The smallest sauries were taken at San Hipolito Bay. The average length of those on the Baja California coast above Cedros Island was four inches during August. Most of the fish below Point Eugenio were 2½ inches (64 mm.).

TABLE 2

Fork Length Measurements of 507 Sauries (Cololabis saira) Taken During 1950-52 Off the Coast of California and Baja California From M/V YELLOWFIN, California Department of Fish and Game

Time	Locality of sample	Number in sample	Average fork length	Range
Central California (Pt. Reyes to Pt. Conception)				
October, 1950	Monterey	20	223	138–271
November, 1950	Pt. Sal	68	239	128–297
December, 1950	Cape San Martin	10	237	223–302
October, 1951	Monterey	11	192	147–237
October, 1951	Pt. Sur	6	230	217–248
October, 1951	Pt. Buchon	20	195	183–217
October, 1951	Pt. Arguello	50	193	151–222
November, 1952	Pt. Reyes	23	208	100–310
November, 1952	Farallon Islands	9	218	211–230
November, 1952	Monterey	5	185	174–200
November, 1952	Monterey	11	195	153–225
November, 1952	Cape San Martin	15	133	120–163
November, 1952	Cape San Martin	16	216	185–247
Southern California (Pt. Conception to International Border)				
November, 1950	La Jolla	22	176	126–223
September, 1951	Santa Cruz Is.	29	179	155–192
September, 1952	Santa Cruz Is.	5	257	237–264
October, 1952	San Clemente Is.	12	248	234–275
Baja California (International Border to Magdalena Bay)				
July, 1952	Pt. Eugenia	13	135	123–156
July, 1952	San Hipolito Bay	14	55	41–90
August, 1952	Descanso Pt.	8	140	136–147
August, 1952	Pt. Banda	13	146	136–167
August, 1952	Cape Colnett	41	82	59–145
August, 1952	Cape Colnett	36	97	71–135
August, 1952	Pt. Canoas	50	192	144–229

PARASITISM

One particular hindrance to ready use as a canned food would be the degree to which sauries in some areas are infected with the parasitic sea louse *Penella* sp. This copepod embeds in the musculature, and a degeneration of its body parts occurs. During this process a thread-like egg-bearing organ develops outside the body of the saury. This dark stringy organ gives the fish an unwholesome appearance. More often, however, a small, round scar caused by the infestation was seen. Few sauries anywhere were without at least one such scar, although samples were taken where no infection of any kind was visible.

Some samples were taken for both measurement and examination for parasitic infection (Table 3). The fish were considered blemished if either the parasite was present or if the scar of attachment was visible. Heaviest incidence of parasitism was observed off central California. Sauries seen in the southern latitudes of the surveyed region were consistently free of signs of parasitism.

TABLE 3

Fork Lengths of 250 Sauries (Cololabis saira) Infected With a Sea Louse (Penella sp.) From the Coast of California and Baja California, 1950-52

Date	Locality	Number in sample	Average fork length	Percent with infection	Average length of scarred fish
October, 1950	Monterey	16	223	80	232
November, 1950	La Jolla	22	176	45	181
November, 1950	Pt. Sal	68	239	81	246
December, 1950	C. San Martin	10	237	20	226
September, 1951	Pt. Descanso	30	103	23	103
October, 1951	Pt. Arguello	50	193	18	198
September, 1952	Pt. Banda	13	146	8	133
September, 1952	C. Colnett	41	82	0	----------

PROXIMATE ANALYSIS

Dr. H. N. Brocklesby, Terminal Island, California, kindly supplied data on the gross chemical composition of two samples of sauries taken March, 1953 (Table 4).

TABLE 4

Chemical Analysis of Sauries (Cololabis saira) Taken in March, 1953, From Waters Off Baja California, Mexico

Locality	Number in sample	Average length, inches	Moisture	Crude protein	Fat content	Ash, (mineral matter)
Cedros Island	4	6	70.90%	21.31%	4.65%	2.90%
Turtle Bay	7	8	71.10%	21.88%	3.80%	3.20%

BEHAVIOR

One of the best ways to detect a large school of sauries at night was to see light reflected from their bodies. The quick flash of a spotlight would then invariably reveal countless more. Any large group which was exposed to deck lights would flip and leap vigorously when the lights were turned out. On the YELLOWFIN a 750-watt bulb and 20-inch reflector was suspended 8 to 10 feet above the water to attract fish when the ship was drifting. Schools of great size have also attracted attention by the roar of the water as they leaped and splashed. Sauries were seen at one time nearly 500 yards away after this splashing had been heard above the usual shipboard noises. A Fathometer generally did not pick up a saury school because of the fishes' tendency at night to remain in the upper one or two fathoms.

Not many species of fish were seen with sauries. Rather often fingerling halfmoons (*Medialuna californiensis*) were taken in saury samples. The bulk of these occurrences during 1952 was in Mexican waters near Sebastian Vizcaino Bay. Off the California coast the only mixed schools were observed near Monterey in October, 1951. Present at that time

with the sauries were juvenile smelt (Osmeridae) and Pacific herring (*Clupea pallasi*). On one occasion a solitary adult sardine was observed harrying a group of small sauries.

Sharks and sea lions prey on the saury. On several occasions near the Channel Islands when schools were attracted alongside the vessel, blue sharks (*Prionace glauca*) swam into the turbulent masses to feed on the sauries. California sea lions (*Zalophus californius*) are diligent in pursuing and capturing sauries.

SUMMARY

In the course of a fishery survey along the coasts of California and Baja California, Mexico, from 1950 to 1952, observations were made of the occurrence and behavior of the saury, *Cololabis saira*.

The work was done at night in waters generally less than 50 fathoms deep. The sauries were attracted by a light, and samples were obtained by dynamite. Dense schools of the fish responded to searchlight rays by leaping from the water.

The greatest number of adult, commercial-sized fish were seen in the Santa Barbara Channel during the fall and winter. Large groups were noted at other points between San Diego and Point Reyes. Typically, the fish were near the surface in a layer seldom thicker than three fathoms.

Sauries occurred throughout most of the study area both in small, scattered groups and in dense aggregations. Adults were seen north from Cedros Island and smaller fish north from Cape San Lazaro. Nursery grounds were apparently located on the northern coast of Baja California.

Approximately 500 sauries were used for measurements of length. Those from California waters were eight to ten inches (193 to 240 mm.) on the average, while those from the Mexican coast were less than six inches (152 mm.).

Infections of copepod parasites marred the appearance of sauries. In California waters these infections occurred in excess of 20 percent of the sample.

Occurrences indicated that a seasonal abundance took place in the coastal waters of the survey. Sauries were very scarce during the mid-year, while dense shoals were seen most frequently during the late fall and winter in Southern California. Other fish species were rarely present in saury schools.

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OBSERVATIONS ON THE SEXUAL BEHAVIOR AND SPAWNING OF THE SQUID, *LOLIGO OPALESCENS*, AT LA JOLLA, CALIFORNIA[1]

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INTRODUCTION

It has long been known that the Pacific Coast squid, *Loligo opalescens* Berry, tends to migrate to certain inshore areas for spawning. This same habit has been described for certain other species of the genus, *L. pealii* of the Atlantic Coast of North America (Verrill, 1881) and *L. vulgaris* in Northern Europe (Tinbergen and Verwey, 1945). This inshore migration generally occurs in the late spring and summer months in the two Atlantic species. But, according to Fields (1950) the egg masses of *L. opalescens* may be found at Monterey Bay, California, during any month of the year, but the most intense spawning is during April, May, June and July, with a minor peak occurring in November. As a result of the availability of specimens near shore during the spawning period, many studies have been made on the embryology of the genus, and Drew (1911) observed copulation and spawning in the aquarium. However, no one appears to have observed these activities in nature.

An unusually large spawning population of *L. opalescens* appeared in the La Jolla area during February and March, 1953. This provided the author with an opportunity to make direct observations in the field and thus to corroborate and supplement the observations of Drew, Tinbergen, Fields and others.

ACKNOWLEDGMENTS

I wish to thank Mr. Ivan Simpson of the U. S. Navy Electronics Laboratory who was my diving companion during this investigation. Special thanks are due to Mr. Conrad Limbaugh of Scripps Institution of Oceanography, whose instruction in the use of, and whose loan of diving equipment made this investigation possible. I also wish to thank Dr. Martin W. Johnson of Scripps Institution for valuable criticisms and suggestions. Mr. Donald Lear and Mr. Sam Hinton, both of Scripps Institution, also provided me with much valuable assistance.

FIELD AND LABORATORY OBSERVATIONS

On February 16, 1953, a local fisherman reported that the net he had set two days earlier was so heavily laden with squid eggs that he could

[1] Contribution from Scripps Institution of Oceanography. New Series No. 670. Submitted for publication September, 1953.

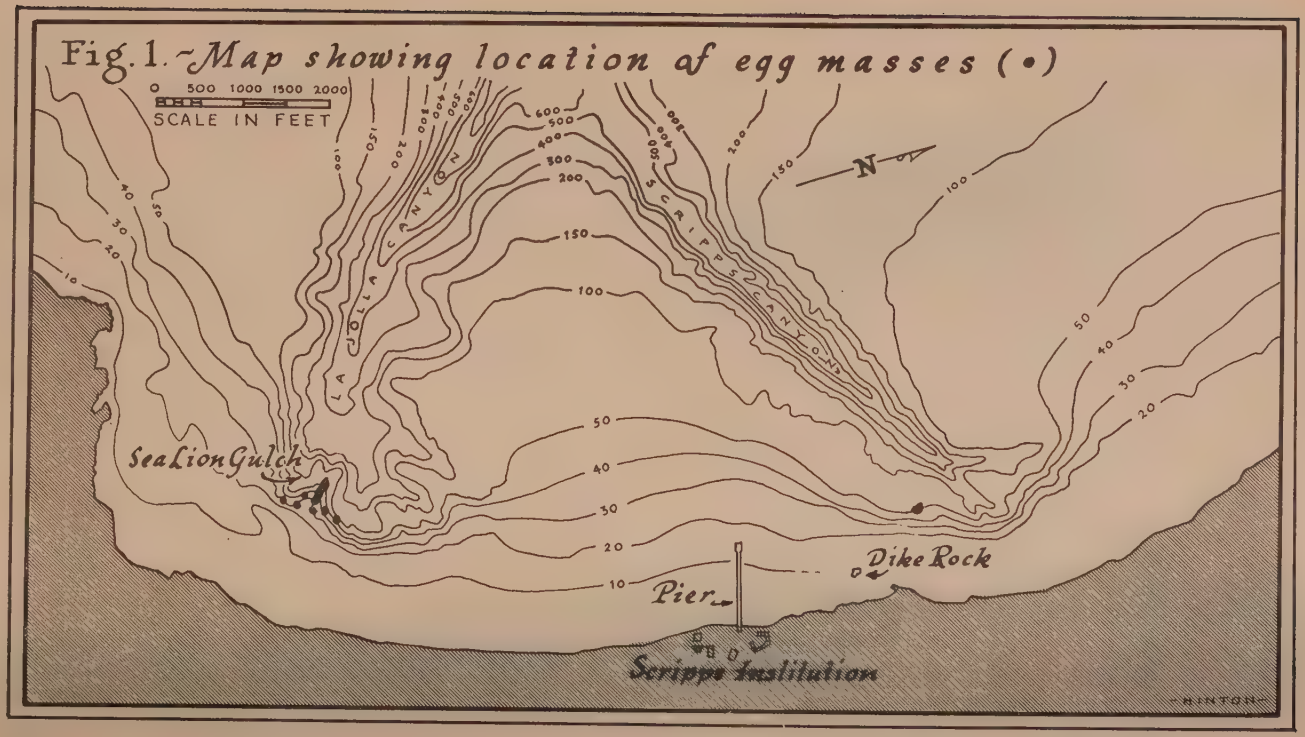
Fig. 1.—Map showing location of egg masses (•)
0 500 1000 1500 2000
SCALE IN FEET
LA JOLLA CANYON
SCRIPPS CANYON
N
Sea Lion Gulch
Dike Rock
Pier
Scripps Institution
HINTON

FIGURE 1

not raise it out of the water. Through interviews with this and other fishermen, it was learned that large schools of squid had been in the vicinity of the La Jolla submarine canyon about 1,400 feet offshore for a period of about a week. At about this time Aqua-lung divers from Scripps Institution of Oceanography reported large numbers of dead squid lying on the bottom at depth of from 30 to 70 feet. As a result of these reports, a special investigation was made. The methods employed were: (1) diving with the use of an Aqua-lung at various points in the area to explore for the site of the chief spawning areas and to recover eggs; (2) plankton hauls for squid larvae at the surface and near the bottom to determine when hatching took place and how long the larvae remained in the vicinity; (3) rearing of the freshly laid eggs, in the laboratory, to determine the length of time required for the embryos to reach the hatching stage and to obtain freshly hatched larvae to aid in identifying those caught in the plankton.

RESULTS

Diving Observations

The first of a series of dives was made by the author and a companion on March 8, 1953, in the vicinity of the Scripps submarine canyon (Figure 1) at a depth of 50 feet. The bottom of this area is sandy with occasional small rocky outcroppings. The water temperature at this time was 12.6 degrees C. Observations on the bottom indicated that a mass mortality of the adult squid population was taking place; the bottom was littered with dead and dying squid. The estimated concentration of squid was one to two individuals per square foot and this situation held for the entire distance that we were able to survey (75-100 yds.). A large mass of egg capsules was discovered attached to the sandy bottom along the general trend of the 50-foot contour. This mass was estimated to be 10-15 feet in diameter. There were great numbers of actively swimming squid in the immediate vicinity of the mass. Many females were seen depositing their individual egg capsules around the periphery of this mass. The manner in which they deposited their eggs and their activities at this time were similar to those of *Loligo pealii* as described by Drew (1911), except that the egg capsules were never attached to protruding objects such as shells or rocks but always to the base of some previously laid egg capsule. A short distance above the egg mass a number of copulating pairs of squid were seen.

Of the two methods of copulation described by Drew (1911) for *L. pealii* only one was observed in *L. opalescens*. In this method the male is ventral to the female and has his arms and tentacles wrapped around her mantle just posterior to her mantle opening. While in this position the male is able, with his left ventral arm, to grasp the packet of spermatophores as they are extruded from his siphon and insert them into the mantle cavity of the female (Figures 2 and 5). Since all of the pairs in the vicinity of the egg mass were in this position, it appears that this method is employed just previous to egg-laying. However, sperm were also found in the buccal sperm receptacles of the females (Figure 4) and this would indicate that the second method of

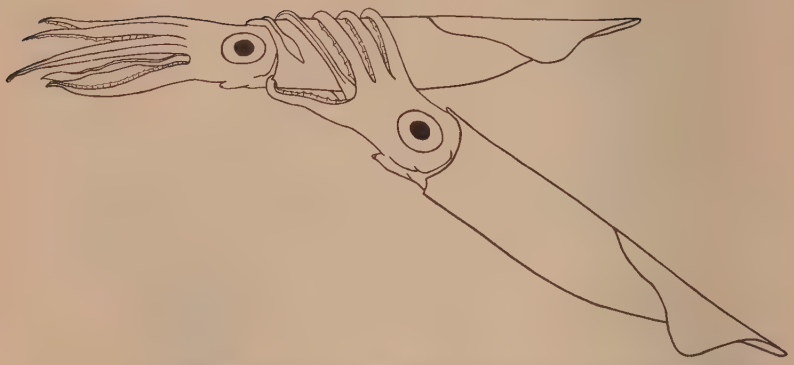

FIGURE 2. Semidiagrammatic illustration of copulating squid showing the animals' position when spermatophores are transferred to the mantle cavity. Drawn from observations in life. Male is embracing female from below.

FIGURE 3. Semidiagrammatic illustration of copulating squid showing the animals' position when spermatophores are transferred to the buccal sperm receptacle. After Drew.

copulation described by Drew (Figure 3) is also used. But since this second method was never observed during any of the dives, it seems likely that the squid use it at some time previous to their arrival on the spawning grounds. A collection of living and dead squid was made at this time.

The next day, March 9th, another dive was made at the head of the La Jolla submarine canyon (Figure 1). The water temperature at this time was 12.4 degrees C. During this dive, large schools of squid were seen in the waters immediately above the canyon. As many as a dozen large egg masses were seen, one was estimated to be at least 40 feet in diameter. These masses seemed concentrated along the edges of the canyon, some of them being on the more gentle slopes and shelves of the canyon wall itself. One such mass, situated on a fairly steep slope, was followed from a depth of about 70 feet down to a depth of 114 feet and appeared to continue on down even farther. At some places in the vicinity of the 40-foot contour, the sandy bottom was completely covered with dead squid. The activities of the squid observed at this time were the same as those seen the previous day near Scripps canyon. A number of squid and freshly-laid eggs were collected. The eggs were promptly placed in an aquarium of running sea water and kept for further study.

The living animals observed on this dive were all very pale and there were large shreds of epithelium hanging down from their mantles. Those collected had a loose flaccid consistency of the body unlike the firmness characteristic of squid caught in open waters during other seasons of the year. This "spent" condition of the population is, according to Fields (1950), a result of spawning and occurs occasionally at Monterey Bay during June and September.

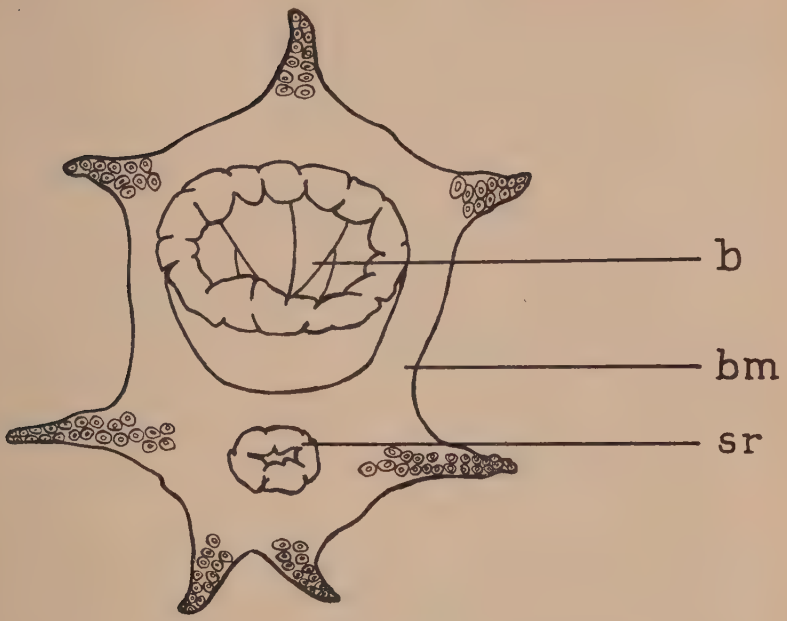

FIGURE 4. Semidiagrammatic illustration of the buccal membrane of the female. (b) beak, (bm) buccal membrane, (sr) sperm receptacle.

During this and the following six weeks, other divers from Scripps Institution, who were engaged in geological research in other parts of the La Jolla Bay region, reported only occasional small groups of egg masses which had become detached from the substrate and were merely lying on the bottom.

As soon as it was apparent that the canyons and their environs were the chief areas of spawning in the bay, all subsequent dives and plankton hauls were made there. Since it was impossible to make routine surveys of both canyon spawning areas, it was decided to follow one relatively small spot where the spawning seemed to be most intense. The area selected was that branch of the La Jolla submarine canyon known as Sea Lion Gulch. Dives and bottom and surface plankton hauls were made every third day during the second and third weeks in March. After this, only weekly dives and plankton hauls were made for the next five weeks, weather permitting.

Laboratory Observations on Animals Collected by Diving

Measurements made on random samples of dead and dying adult squid taken from the bottom gave a modal size of from 15-16 cm. mantle length for the males and from 14-15 cm. mantle length for the females. This is one centimeter smaller than the modal sizes for both males and females of the Monterey Bay spawning population of *L. opalescens* (Fields, 1950), and 5 cm. smaller than the males and 2 cm. smaller than the females of a spawning population of *L. vulgaris* at Helder, Netherlands (Tinbergen and Verwey, 1945). The sex ratio obtained from this

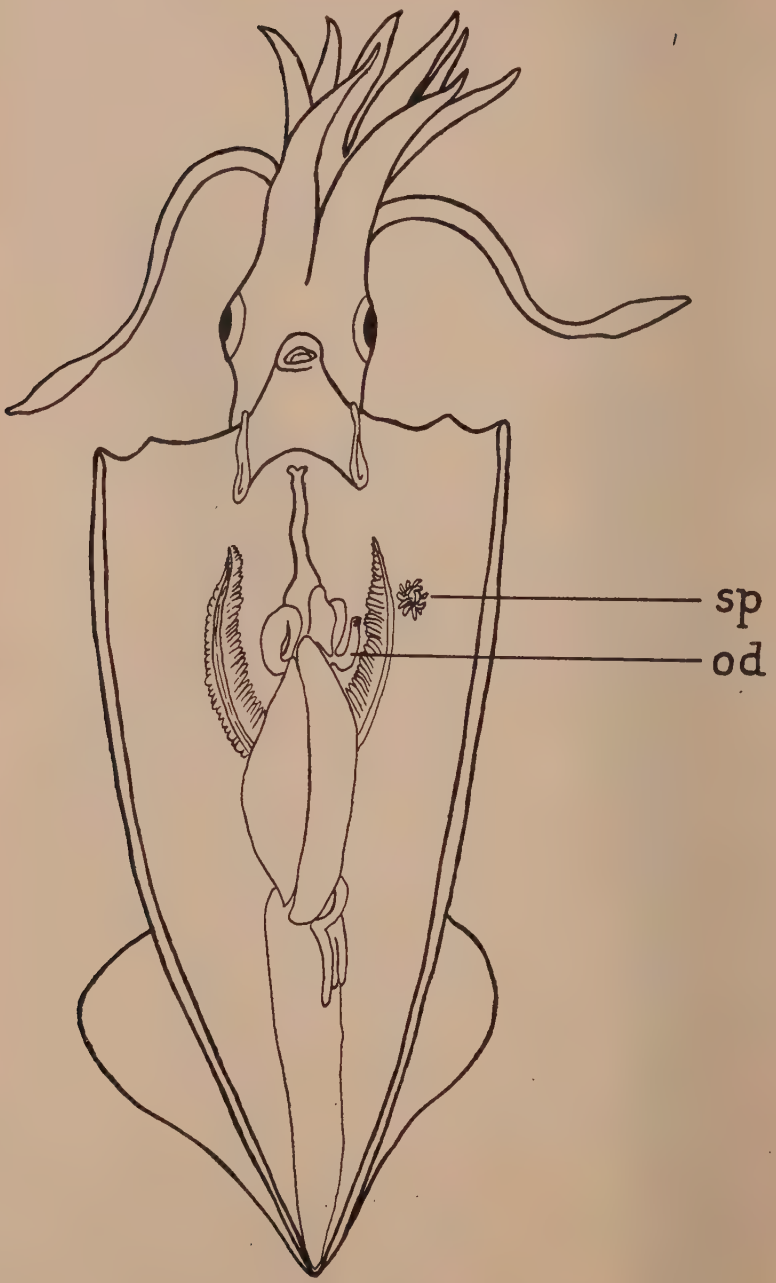

FIGURE 5. Ventral view of female with mantle laid open to show place of attachment of spermatophores under mantle. (sp) spermatophores, (od) oviduct.

sampling was unequal, the males comprising 63 percent of the population. According to Tinbergen and Verwey (1945) the sex ratio of their spawning population was unequal, 57 percent being males.

An examination of the guts of the females showed them to be completely empty. The guts of the males contained only a few shreds of mantle epidermis which had apparently been torn from the female.

Results of the Plankton Hauls

A 40 cm. Hansen type plankton net was used to make 10-minute hauls over the vicinity of Sea Lion Gulch. These hauls were made at the surface and as close to the bottom as possible, for a period of six weeks after the main spawning was observed. Only four larval squid were caught in these hauls, although diving observations made at the time the plankton hauls were taken indicated that the number of egg capsules in the vicinity was progressively decreasing. While it would have been more desirable to use a larger net and to cover a larger area of the bay, it is believed that the results of the plankton hauls taken are significant and that they indicate that the larval squid did not stay in the vicinity of the spawning grounds but were swept away by currents.

Result of Egg Rearing in the Laboratory

The freshly laid egg capsules which were brought into the laboratory were maintained in aquaria of running sea water at an average temperature of 13.6 degrees C. The egg capsules are from 3½ to 4 inches long when first laid but swell to 8 or 10 inches within a few days. Development to hatching stage required from 30 to 35 days. The freshly hatched larvae have an over-all length of 4.5 mm. and a mantle length of 2.5 mm. There was a 25 percent mortality of the eggs. This mortality, however, was apparently induced by laboratory conditions because the eggs in nature, observed by diving, showed no mortality, even up to the hatching stage. The larvae hatched in the laboratory still had a very small yolk sac. This sac persisted for about a day. No attempt was made to rear the larvae beyond this stage.

It was noticed that after about the second week the egg capsules which were kept in the laboratory were infected with a large, bright red polychete worm *Capitella ovincola* (identified by Dr. D. J. Reish). The egg capsules which were observed in nature at this time were also parasitized by *C. ovincola*. The worms did not appear to be feeding upon the developing embryos but merely to be boring through the gelatinous matrix of the egg capsule. As many as 15 of these worms were found in a single egg capsule. The egg capsule also provided a substrate for two other organisms, the hydroid *Obelia geniculata* (identified by Dr. Cadet Hand) and naviculoid diatom.

SUMMARY

The sequence of events in the spawning of *L. opalescens* as based on the above observations and on those of other authors seems to be as follows: (1) a population which is ready to spawn moves from offshore into a relatively shallow area near shore. It seems probable that at this time the males transfer sperm to the buccal seminal receptacles of the females. (2) The squid tend to congregate near the sandy bottoms of

semiprotected bays. (3) A few minutes before the females lay their eggs the males transfer a second group of spermatophores to a place under the left side of the mantles of the females. (4) The females attach their egg capsules either to the sandy bottom or to the base of some previously laid egg capsule. This results in large masses of egg capsules, which may be as much as forty feet in diameter. (5) Both males and females die after spawning. (6) The eggs require from 30 to 35 days to hatch at a temperature of 13.6 degrees C.

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THE PACIFIC MACKEREL FISHERY IN THE 1951-52 AND 1952-53 SEASONS[1]

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The purpose of this paper is to bring up-to-date the catch statistics for the Pacific mackerel (*Pneumatophorus diego*) fishery with particular reference to the Los Angeles region. Data for previous seasons were presented by Roedel (1952). The season is defined as commencing in May and ending in April.

The outstanding development in 1951-52 and 1952-53 was the virtual disappearance of the scoop fishery. As a corollary, the total catch declined to its lowest level since the depression years of 1930-1933. Analyses of the age composition of the catch (Fitch 1952, 1953a,b) have shown that the catch has become increasingly dependent upon the strength of incoming year classes. There is no evidence of good spawning success in recent years, and the fishery in the period under discussion was dependent largely upon the good 1947 year class and the fair 1948 class. These fish were five and four years old respectively in 1952-53. Over the 12-season period 1939-40—1950-51, about 87 percent of the total catch consisted of fish less than four years of age. Obviously, no improvement can be expected in the future until there is a succession of better-than-average year classes.

As has always been the case, the great bulk of the catch continued to be delivered in the Los Angeles region (Los Angeles and Orange Counties). Annual state-wide landings for 1951 and 1952 (Table 1) show 1952 with 10,302 tons to be the worst year on record since 1932, when 6,236 tons were brought ashore. Contrary to the general downward trend, San Diego experienced its best season since 1942 (904 tons) in 1952 (606 tons).

TABLE 1

Annual Landings in Tons of Pacific Mackerel

Year	Region				Total
	Monterey	Santa Barbara	Los Angeles	San Diego	
1951	179	388	16,000	192	16,759
1952	126	20	9,550	606	10,302

[1] Submitted for publication September, 1953.

The Los Angeles region fishery reached its peak in October during the 1951-52 season and in July in 1952-53. Early season (May-August) catches were actually fairly good in both seasons. Midseason (September-December) catches were poor, however, with mid-1952-53 the worst such period since 1932-33. Landings in the late season (January-April) were very small. Over the 23-season period 1928-29—1950-51, the midseason was by far the most productive, accounting for nearly 68 percent of the entire catch.

The outstanding feature of the two seasons, as noted earlier, was the continued decline of the scoop fishery in 1951-52 and its virtual disappearance in 1952-53, when only 325 tons of scoop-caught mackerel were landed. The bulk of the catch originated at Santa Catalina Island. At its peak, 1944-45, the scoop fishery produced over 30,000 tons.

TABLE 2

Landings in Tons of Pacific Mackerel, Los Angeles Region

	Season		25 seasons (1928-29—1952-53)	
	1951-52	1952-53	Tons	Percentages
May	100	464	23,480	3.4
June	158	941	23,993	3.4
July	975	2,989	46,077	6.6
August	3,329	1,643	65,365	9.3
Early season	4,562	6,037	158,915	22.7
September	1,359	1,062	118,089	16.9
October	7,265	1,238	154,119	22.0
November	1,731	856	117,939	16.8
December	113	76	80,055	11.4
Midseason	10,468	3,232	470,202	67.1
January	199	53	39,197	5.6
February	9	32	18,898	2.7
March	25	1	10,516	1.5
April	48	7	2,651	0.4
Late season	281	93	71,262	10.2
Season totals	15,311	9,362	700,379	100.0

TABLE 3

Pacific Mackerel Landings in Tons by Gear, Los Angeles Region

Gear	Season		14 seasons (1939-40—1952-53)	
	1951-52	1952-53	Tons	Percentages
Seine	12,850	9,022	154,024	39.8
Scoop	2,435	325	227,286	58.8
Other and unknown	26	15	5,352	1.4
Totals	15,311	9,362	386,662	100.0

TABLE 4

Monthly Landings in Tons of Seine- and Scoop-caught Pacific Mackerel, Los Angeles Region

	Seine				Scoop			
	1951-52	1952-53	14 Seasons (1939-40—1952-53)		1951-52	1952-53	14 Seasons (1939-40—1952-53)	
			Tons	Percentages			Tons	Percentages
May	100	439	1,336	0.9	0	23	212	0.1
June	130	901	2,554	1.7	26	36	442	0.2
July	958	2,956	12,280	8.0	14	31	822	0.4
August	3,204	1,622	19,990	12.9	119	19	4,211	1.8
Early season	4,392	5,918	36,160	23.5	159	109	5,687	2.5
September	794	879	29,428	19.1	562	179	36,493	16.1
October	5,967	1,202	28,671	18.6	1,292	37	66,015	29.0
November	1,328	855	26,145	17.0	400	0	59,096	26.0
December	92	76	9,892	6.4	20	0	40,097	17.6
Midseason	8,181	3,012	94,136	61.1	2,274	216	201,701	88.7
January	197	53	10,330	6.7	0	0	13,301	5.9
February	9	32	8,518	5.5	0	0	4,573	2.0
March	25	0	3,917	2.6	0	0	1,944	0.9
April	46	7	963	0.6	2	0	80	0
Late season	277	92	23,728	15.4	2	0	19,898	8.8
Totals	12,850	9,022	154,024	100.0	2,435	325	227,286	100.0

TABLE 5

Catches in Tons by General Fishing Area of Pacific Mackerel, Los Angeles Region

Fishing area	Seine				Scoop			
	1951-52	1952-53	14 Seasons (1939-40—1952-53)		1951-52	1952-53	14 Seasons (1939-40—1952-53)	
			Tons	Percentages			Tons	Percentages
Santa Monica	979	477	22,870	15.9	1	4	95,808	44.2
Newport	1,493	1,032	21,604	15.0	245	74	79,281	36.5
Santa Catalina	116	457	20,337	14.1	2,001	137	41,942	19.3
Total, local	2,588	1,966	64,811	45.0	2,247	215	217,031	100.0
Northern	3,551	52	40,486	28.2	---	--	------	----
San Nicolas	4,154	57	15,791	11.0	---	--	------	----
San Clemente	2,235	1,847	14,813	10.3	- -	-	------	---
Tanner and Cortes Banks	3	4,432	4,435	3.1	---	--	------	----
San Diego	50	326	3,502	2.4	---	--	------	----
Total, distant	9,993	6,714	79,027	55.0	- --	--	-- - -	---
Total, known origin	12,581	8,680	143,838	100.0	2,247	215	217,031	100.0
Total, unknown origin	269	342	10,186	----	188	110	10,255	----
Totals	12,850	9,022	154,024	----	2,435	325	227,286	----

Seiner catches about held their own when compared with the period 1941-42—1950-51. However, the 1952-53 catch was maintained only because the seiners extended their operations into a hitherto virtually unexploited area comprising Tanner and Cortes Banks. These banks lie, respectively, about 30 and 40 miles southwest of San Clemente Island. Because of weather conditions and because of their distance from port, they were rarely fished in previous years. The usual fishing grounds were extremely unproductive in 1952-53.

Tables 2 to 5 present detailed data for the two seasons with cumulative totals carried forward from similar tables presented by Roedel (1952). Records of total landings (Table 2) cover the 25-season history of the fishery which first became of major importance in 1928-29. Records by gear (Tables 3-5) cover the 14-season period commencing in 1939-40 when the scoop fishery first became of major importance.

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A NOTE REGARDING THE TOXICITY OF THE FISHES OF THE SKIPJACK FAMILY, KATSUWONIDAE[1]

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During August, 1950, there was an outbreak of fish poisoning at the 1505 Air Base Group, U. S. Air Force, at Johnston Island (lat. 16° 45′ N, lon. 169° 30′ W), involving a communications sergeant, his wife, two children and the family cat. The causative agent was a black skipjack, believed to be *Euthynnus yaito* Kishinouye. The specimen was described as a "tuna-like" fish having dark spots in the region of the pectoral fin and stripes along the sides. The fish was captured in the vicinity of the northern peripheral reef of Johnston Island. No other information regarding the fish was available. The fish was taken home, cleaned and cooked within a short time after capture, so there was no opportunity for spoilage. Neighbors stated that they had captured this same species of fish on previous occasions and had eaten it without ill-effects.

A few hours after the meal, all of the members of the family developed nausea, vomiting, tingling and numbness of the lips, mouth and extremities, cold clammy skin, mild diarrhea, intestinal cramps, weakness, muscular aches, palpitation, and mild to moderately severe prostration. The acute phase of the episode lasted about 36 hours and then gradually the symptoms subsided. The convalescent period was slow, lasting several weeks, during which time weakness and muscular pains were the predominant symptoms present. Treatment was of a nonspecific type. Within a period of two months, the family had completely recovered. The family cat, which had eaten a liberal portion of the fish, became very ill, afflicted with vomiting and diarrhea, but appeared to have recovered within a period of 24 hours. The patients were examined by Dr. John T. Martin, formerly base surgeon at Johnston Island, to whom I am indebted for the preceeding clinical data.

Dr. D. V. Villadolid, Director of Fisheries of the Philippine Bureau of Fisheries, recently reported (*in litt.*) a series of outbreaks which occured on January 9 and April 9 and 10, 1951, in Manila, Philippine Islands, as a result of eating freshly caught *Katsuwonus pelamis* (Linnaeus). A total of five persons was involved. The symptoms developed in about 20 minutes and consisted of acute abdominal pain, dizziness, dryness of the throat, stiffening of the muscles of the extremities, and an urge to defecate and urinate, but an inability to do so. All of the patients recovered within a few days.

[1] This investigation was supported by a research grant from the National Institute of Health, Public Health Service, and a contract with the Office of Naval Research, Department of the Navy (Contract No. NONR205(00). Submitted for publication September, 1953.

Numerous references appear in the literature regarding the toxic properties of various scombroid fishes. Scrutiny of these accounts will reveal that in most instances they are not referring to ichthyosarcotoxism, true fish poisoning, which is caused by a neurotoxin that is present in the tissues of the fish, but rather to bacterial food poisoning resulting from spoilage. However, some of the accounts are concerned with a type of histamine intoxication which appears to be caused not infrequently by certain tropical scombroid fishes. In most instances these histamine outbreaks have resulted from eating tuna, bonito or skipjack, which are a day or more old, rather than from freshly caught fish. Inadequate refrigeration or failure to cook the fish promptly after capture appear to be significant contributing factors.

The symptomatology occurring in histamine intoxications caused by scombroid fishes has been described by Henderson (1830), Autenrieth (1833), Meyer-Ahrens (1855), Morvan (1857) and Knox (1888). The symptoms listed in these accounts can be summarized as consisting of nausea, vomiting, redness and flushing of the face, engorgement of the soft tissues of the eyes, swelling and cyanosis of the lips, tongue and gums, giant urticaria, severe itching, headache and respiratory distress. The symptoms generally develop within a few minutes after ingestion of the fish, and the victim usually recovers within 8 to 12 hours. In some instances patients have stated that the fish had a sharp "peppery" flavor. These symptoms are typical of a histamine reaction and not a neurotoxin such as is observed in most types of ichthyosarcotoxism, nor are these symptoms characteristic of ordinary bacterial food poisoning. Günther (1880), Jouan (1867), Maas (1937), Phisalix (1922) and Tybring (1887) all list *Katsuwonus pelamis* (Linnaeus) as toxic, but do not go into detail regarding the clinical characteristics of the intoxication.

Legroux, Bovet and Levaditi (1947) obtained a large piece of "tuna" which had caused a severe histamine reaction in four persons. Bacteriological examination of the sample for human pathogens was negative. Intramuscular injections of tissue extracts of the "tuna" into guinea pigs resulted in nervousness, inactivity, muscular tremors, convulsions and death within five minutes. Boiling the extract for 20 minutes in a water bath did not inactivate the toxic substance. Also, it was observed that pretreatment of the guinea pigs with antihistamines protected the animals from any untoward reactions when the tissue extracts were injected. The authors thus came to the conclusion that histamine was present in the "tuna" and probably resulted from the decarboxylation of histidine, a normal constituent of fish flesh. There was some question as to the exact mechanism of histamine production, but suggested the possibilities of bacterial enzyme action, aseptic cytolysis, or a normal physiological condition of the fish during spawning season.

The Johnston Island outbreak is particularly noteworthy in that the victims developed neurotoxic symptoms as a result of ingesting a skipjack. Moreover, the symptoms present were typical of the Ciguatera-type of ichthyosarcotoxism such as is commonly produced by most reef fishes (exclusive of moray eels and puffers), rather than the usual histamine reaction that has been observed by previous workers. The Johnston Island outbreak once again points up the need for further

investigation on poisonous fishes and their relationship to the economic development of fisheries resources in the tropical Pacific. Future world demands for protein food sources will necessitate more rigid control and efficient utilization of the vast food reserves of the ocean. The problem of poisonous marine organisms will become of increasing importance in the years to come.

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THE SUMMER FOOD OF SOME INTERTIDAL FISHES OF MONTEREY COUNTY, CALIFORNIA[1]

RICHARD F. JOHNSTON[2]

In a recent paper Mitchell (1953) listed the food items found in 13 species of fish obtained by rotenone poisoning from a large tidepool at Portuguese Bend, Los Angeles County, California, in March, 1949. The present paper is concerned with a similar fauna at a different time of the year, outlining the results of stomach examinations of nine common intertidal fishes collected between June 21 and July 19, 1951, at Mussel Point, Point Pinos, Asilomar Point, Pescadero Point, and Soberanes Point, Monterey County, California.

The fishes were collected with a dip net during low tidal conditions and put into a glass jar and allowed to suffocate; they were then put into 10 percent formalin for preservation before examination. It is well to note that the fish regurgitated the contents of their stomachs if they were put alive into the formalin. The stomachs of larger fishes were injected with formalin to ensure preservation of the contents. Publications used in the identification of the forms encountered included Cupp (1943), Hatch (1947), Light (1941), Oldroyd (1927), and Wilson (1932).

Oligocottus snyderi. Twenty-seven individuals; length 33-66 mm. (average 48). Collected in the lower mid-intertidal zone. One stomach was found to be empty. Algae were found once, forming 90 percent of that stomach mass. The animal matter found included (giving number of individuals and number of fish containing them):

Polychaeta
Eunicidae, 3 (1)
Sabellidae, 2 (1)
Unidentified, 3 (2)

Copepoda
Harpacticoida, 454 (13)
Calanoida, 15 (2)

Chelifera
Antenais normani, 18 (3)

Isopoda
Exosphaeroma sp., 6 (4)

Gammaridea
Hyale sp., 73 (14)
Melita sp., 83 (2)

Caprellidea, 2 (2)

Staphylinidae
?*Liparocephalus* sp., 27 (3)

Gastropoda
Acmaea sp., 1
Margarites sp., 1
Lacuna sp., 1

Bryozoa
Cheilostomata, 1 fragment

Oligocottus rubellio. Four; 41-75 mm. (60). Lower mid-intertidal zone. No plant matter found.

Polychaeta
Terebellidae, 1
Eunicidae, 1
Nereidae, 1
Unidentified, 2 (1)

Chelifera
Antenais normani, 2 (1)

Gammaridea
Hyale sp., 19 (3)

Decapoda
Pagurus sp., 1

[1] Submitted for publication September, 1953.
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Clinocottus analis. Thirty; 31-120 mm. (52). Higher mid-intertidal zone. One stomach empty (120 mm. ovigerous ♀). Algae, primarily *Ulva*, detected in eight individuals: a trace in five, and 30 percent, 50 percent, and 100 percent of the stomach mass in the remaining three.

Ascaroida, 3 (2)
Sipunculoida
Physcosoma agassizi, 2 (1)
Polychaeta
Eunicidae, 11 (1)
Lumbrineridae, 15 (4)
Unidentified, 6 (3)
Ostracoda
?*Cythereis* sp., 9 (7)
Copepoda
Harpacticoida, 1368 (25)
Calanoida, 12 (4)
Chelifera
Antenais normani, 17 (5)
Isopoda
Exosphaeroma sp., 8 (2)
Cirolana harfordi, 38 (3)
Gammaridea
Hyale sp., 27 (7)
Melita sp., 1
Caprellidea, 2 (2)
Decapoda
Megalopa larva, 3 (2)
?*Spirontocaris* sp., 1
Pagurus samuelis, 1
Acarina
Halicaridae, 2 (1)

Clinocottus recalvus. Fifteen; 24-58 mm. (37). Lower mid-intertidal zone. Chloro- and bacillario-phytous algae were detected in 12 individuals; the occurence ranged from a trace to four cases of 90 to 100 percent incidence per stomach. Diatoms of the suborder Pennatae were most abundant. *Nitzschia* and *Surirella* were identified to genus but neither was commonly found.

Ascaroida, 6 (5)
Sipunculoida
Physcosoma agassizi, 1
Ostracoda
?*Cythereis* sp., 1
Copepoda
Thisbe furcata, 199 (10)
Cirripedia
Tetraclita squamosa, cirri (2)
Chelifera
Antenais normani, 5 (4)
Isopoda
Idothea sp., 1
Gammaridea
Melita sp., 1
Decapoda
?*Spirontocaris* sp., 1
Coleoptera, 1
Echinoidea
Strongylocentrotus sp., tube-feet (2)

Gobiesox maeandricus. Eight; 46-82 mm. (58). Mid-intertidal zone. Two stomachs empty. No plant material found.

Polychaeta
Syllidae, 1
Ostracoda
?*Cythereis* sp., 3 (2)
Copepoda
Harpacticoida, 215 (3)
Cyclopoida, 7 (1)
Isopoda
Exosphaeroma sp., 5 (4)
Gammaridea
Allorchestes sp., 2 (1)
Melita sp., 2 (1)
Gastropoda
Acmaea sp., 1
Cingula sp., 8 (4)
Littorina sp., 3 (3)

Gibbonsia metzi. Five; 36-78 mm. (54). Lower intertidal zone. Two stomachs empty. No plant matter found.

Copepoda
Thisbe furcata, 4 (2)
Gammaridea
Hyale sp., 1
Decapoda
?*Spirontocaris* sp., 2 (2)
Gastropoda
Acmaea sp., 1
Crepidula adunca, 1

Epigeichthys atropurpureus. Two; 81, 134 mm. Mid-intertidal zone. One stomach was empty, the other had 60 percent of its mass as algae, plus two unidentified polychaetes, 25 harpacticoid copepods, and two gammarids.

Xiphister mucosus. Three; 26-96 mm. (70). Mid-intertidal zone. One stomach empty and one with 90 percent of the gastric mass as *Ulva*.

Copepoda
Harpacticoida, 1

Gammaridea
Hyale sp., 2 (2)
Allorchestes sp., 7 (1)

Xererpes fucorum. Three; 77-125 mm. (107). Mid-intertidal zone, in *Phyllospadix*. No plant material found.

Ostracoda
?Cythereis, sp., 54 (3)

Copepoda
Harpacticoida
Peltidiidae, 108 (2)
Thisbe furcata, 7 (2)
Tigriopus sp., 202 (2)

Isopoda
Exosphaeroma sp., 1

Gammaridea
Hyale sp., 5 (2)
Allorchestes sp., 3 (1)
Melita sp., 3 (2)

Decapoda
Pagurus samuelis, 2 (1)

DISCUSSION

The roundworms were less than 0.5 mm. in length and resembled planktonic forms that occurred in Monterey Bay at the same time of year. There was no indication that the worms were secondarily derived from other animals eaten.

Of the polychaetes, eunicids and lumbrinerids appeared with greater frequency in stomachs from fishes taken in June. Some of the worms were tube-builders, but there was no evidence of tubes in any stomach.

Copepods were a numerous and stable food item, especially for fish under 50 mm. in total length. An orange harpacticoid, apparently a species of *Tigriopus*, was found most abundantly.

The cirri of the barnacle *Tetraclita squamosa* were the most numerous animal remains in the stomachs of two specimens of *Clinocottus recalvus*; these fish were taken at Pescadero Point on July 19. The cirri were present in sufficient amount and of such uniform size that it is highly probable that the fish purposely took them from living barnacles, and had not merely grubbed cast molts from off the bottom of a pool.

The insect larvae and parts that appeared in small numbers were apparently all of the same general kind; however, it was not possible to identify all that were found. The heads of the insects bore a strong resemblance to the head of the staphylinid *Liparocephalus* as figured in Chamberlin and Ferris (1929: fig. 5, D). Probably the insects were dislodged by waves from their niches in the splash zone, as they were taken by fishes occurring normally in the mid-intertidal areas.

The tube-feet from *Strongylocentrotus* were found in the same individuals of *Clinocottus recalvus* that had taken barnacle cirri. The pigment in the tube-feet had diffused out to dye the gastric mucosa a deep, pink color and also to color the stomach contents variously from pink to purple.

Mitchell (*op. cit.*) found 42+ species in his larger sample. The present report lists over 40 forms, but of a different and wider group of invertebrates. This proportionally larger representation is what would be expected *a priori* from a collection made in the summer months. A further and larger increase in the number and variety of forms, especially for the summer months, would have been gotten if more specimens of *Gibbonsia metzi* and *G. elegans* had been collected, as well as larger fishes (certain embiotocids and rockfish) that forage in the intertidal areas during high tides; indications from small samples collected at different points along the California coast are that, when they are able, the larger fish definitely utilize the intertidal fauna as a food source, thus entering integrally into the picture of intertidal ecology.

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ON THE SUPPOSED STENOBATHIC HABITAT OF THE CALIFORNIA SEA-MUSSEL[1]

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ABSTRACT

The California sea-mussel is frequently stated to be exclusively intertidal in habitat, and the occurrence of empty valves in off-shore hauls has even been cited as evidence of recent strong orogenic movement. However, the ease with which these animals may be maintained in well-aerated aquaria for extended periods without benefit of either pounding surf or tidal oscillation might well have prepared us for the ever increasing discoveries by southern California divers of rich beds of this species in suitable areas considerably below tide-level. The recovery from bay dredgings at San Pedro of a fairly fresh valve of this *Mytilus* bearing numerous attached examples of the small deep-water brachiopod *Platydia,* while not in itself conclusive, is of value as evidence. More definitive is the capture of a very large living individual (long. 228 mm.) in 48 fathoms, southwest of Seal Rock Light, Humboldt County, California. The presumption is strengthened accordingly that *M. californianus* is very much more eurybathic than has prevailingly been assumed.

The common California sea-mussel is by far the most prevalent and conspicuous member of its family along our shores, occurring in untold masses and numbers from boundary to boundary wherever surf and rocks meet. So characteristic is it of such situations that the assumption is often made that it is confined to them. For example we may cite among many others the observation of Hewatt (1937:186), "There are certain organisms which apparently can survive only on the rocks which are subjected to severe wave action. *Mytilus californianus* forms beds several inches in thickness on the rocks of the surf swept area." And again that of Ricketts and Calvin (1952:163), "Here is another animal that is distinctly at home in crashing waves. Indeed it occurs only where there is surf." Taking for granted this concept of a narrow vertical range for this species, some have even gone so far as to make it the assumptive basis for ideas of far wider import, as quite recently does Hanna (1952:345) in writing concerning the geologic history of central California: "There is additional evidence of relatively recent subsidence of a lesser magnitude. This consists of the presence of intertidal shells of *Mytilus californianus* at several places down to 50

[1] Submitted for publication August, 1953.

FIGURE 1. *Mytilus californianus* Conrad. Exterior of left valve of specimen trawled in 48 fathoms, S. W. of Seal Rock Light; x ca. ¾.

fathoms. They were especially noticed around Cordell Bank which is 30 miles from the nearest shoreline. All which were recovered were very old 'dead' shells but would not be classed as fossils. . . . Cordell Bank, 34 fms. About 100 pounds of granitic fragments. Most of these were heavily encrusted with organisms and some contained borings up to one inch in diameter. These holes are very old and are exactly like those made by mollusks such as *Pholadidea ovoidea* but in no case was there a trace of shell remaining. This together with the presence of very old shells of *Mytilus californianus* in the same haul, indicates strongly that at no very distant date Cordell Bank was intertidal."

Gradually accumulating meanwhile in both field and laboratory is a body of evidence that *Mytilus californianus* is in actual fact by no means so stenobathic as quotations such as the foregoing would indicate, and that any wider conclusions drawn upon that assumption are not, in this respect at least, soundly founded. We have first the important and suggestive observations of Fox (1936: 2) who states: "This mollusk . . . can be maintained in a healthy condition for indefinite periods in laboratory aquaria that are adequately aerated or provided with running sea water." And (*ibid.*, p. 9): "Aeration is a factor very beneficial to the prolongation of the life span of *M. californianus* in water of any salinity that is not fatal in a short time." And further (*ibid.*, p. 61): "*Mytilus californianus* is capable of surviving long periods of immersion in aerated sea water of widely different salt concentrations, varying from hypotonic solutions of about half the salt content of natural sea water to hypertonic solutions which are about one-third again as concentrated in sea salts. This heterosmotic adaptation on the part of the mussel would permit of an extended range of habitation." Even Ricketts and Calvin, despite the comment previously quoted, made the further suggestive observation (1952:163) that "The mussel, *Mytilus californianus* . . . forms great beds that extend in favorable localities from above the half-tide line to well below extreme low water"; while Fitch (1953:52) is also somewhat less dogmatic than others when he writes, "*Habits:* Attached to rocks by the byssus, sometimes in great masses between the tide lines where it is directly exposed to surf. Sometimes attached to pilings on the outer coast with the bay mussel and less frequently inside sheltered bays."

From all this it would appear that aeration of the water affords a more likely clue to the habitat requirements of the California mussel than either intertidal exposure or the violence of surf, and that where such aeration can be brought about in other ways, as either by tidal movement or by strong currents, the species might be expected to become more eurybathic unless other factors were to prove themselves sufficient to block such extension of range.

We should not then have been altogether unprepared when skin divers, exploring off the south Californian coast, began to report in recent years their observation of this mussel on the sea bottom in appreciable numbers and in areas which suggested some difficulty in explaining them as washed there from rocky shores. At one time a few years since, Dr. T. H. Bullock of the University of California at Los Angeles (where much interesting experimental work on this mussel is being done), still affected to some extent in his thinking by the stenobathic reputation of *M. californianus,* even went so far as to suggest (*in litt.*

to author) that the possible involvement of two species might be worthy of serious inquiry. From an examination of the rather scanty and imperfect material available to me, however, I failed to discover any sound taxonomic ground for the suggested separation. The offshore shells appeared to be a little thinner and ran somewhat larger than average intertidal specimens, but as of this date I have quite failed to detect any differences between shells from the respective sources that could in any way be regarded as taxonomically significant.

This first offshore material seen by me was taken by H. J. Jacobs in diving to a depth of seven to fifteen fathoms somewhere near Palos Verdes. Just as I am putting this paper into its final form Dr. Bullock (*in litt.*) adds that "Since then, our own divers have reported beds of mussels of this species several times from Palos Verdes and the vicinity of Pt. Dume in water of 15- to 40-feet depth. We have felt we are dealing with a real disjunct distribution as we have repeatedly looked for and failed to find beds in water from the minus one- to the minus ten-foot level.[2] The beds are real and the specimens brought up are very much alive—we have extensive quantitative data on them, showing for example that they are physiologically like mussels from far to the north . . . and that they show just as good a persistent tidal rhythm [in laboratory aquaria] as intertidal specimens." The important point in the present connection is that the California sea-mussel is shown to have the ability to live and thrive and does so live and thrive well below the tidal zone.

Another bit of evidence to be considered as suggesting the possibility that yet greater depths might lie within the range of this species came to hand in the form of a right valve brought to me by Mr. Emery P. Chace of Lomita who had picked it up, apparently from the bay dredger rejectamenta at San Pedro. This was a "dead" shell which was fresh enough to retain much of the original periostracum as well as some trace of lustre in the nacreous interior, which is, however, dotted with various small encrusting organisms such as young chamids, tubiculous annelids, and a few vermetoid gastropods. The significant point is, however, the circumstance that amongst these is to be found a considerable sprinkling of the minute brachiopod *Platydia* [or *Morrisia*] *radiata* Dall, which is unknown to us above or near the low-tide line, but is regularly reported as living in waters of 25 to 200 fathoms depth (Hertlein and Grant, 1944: 111).

Final proof that *Mytilus californianus* may flourish down to at least half a hundred fathoms lies in a specimen which has lately been submitted to me through Mr. John E. Fitch by Mr. Ralph B. McCormick of the California Department of Fish and Game at Eureka. This is a magnificent example (Berry Coll. No. 17235) measuring in longitude approximately 228 mm., altitude 89.5 mm., diameter 69.2 mm., which was taken alive by the Trawler WINGA, Skipper Byron Anderson, in 48 fathoms, southwest of Seal Rock Light, CF & G Block 109, off Humboldt County, California. The shell is not only large for the species, but quite

[2] Nevertheless Mr. John E. Fitch has lately reported to me a quite different situation observable westward from the lighthouse on the Long Beach (federal) breakwater, where the mussels appear first just below the high tide line and are found in an unbroken mat from there to a depth of 30 feet or more. At one locality there were large clumps of mussels attached to rocks in 33 feet of water (measured with a depth gauge attached to wrist). Typical shells from about 12 feet down measure from 153 to 204 mm. in length.

thin, and the contracting periostracum is already causing a serious splitting of the right valve. As usual there is a scattered incrustation of baby barnacles and bryozoans as well as a few bristly algae. The major growth ridges would indicate an age of a considerable number of years, seven or eight if all of the larger ones are genuinely annual, or possibly even more than that. This specimen is illustrated in the accompanying figure. We have of course yet to learn whether a situs so far off-shore is a genuinely normal one, or whether by some means, such as being dropped by a gull, such occurrences are but adventitious or sporadic. In any event this mussel is at least able to live and maintain itself to maturity in waters of considerable depth. It is of interest that the specimen studied was found to contain a female commensal crab, measuring 16 mm. across the carapace, the species of which has been determined as *Fabia subquadrata* (Dana).

The tendency toward a greater size off-shore appears to be directly opposite to the situation with the common edible mussel (*M. edulis*) in England, where examples are likewise sometimes brought in from off-shore but are then reported (White, 1937 : 5) to be much below average intertidal size.

Grateful acknowledgment is due to Dr. T. H. Bullock and Mr. John E. Fitch for some of the more consequential data used in the foregoing discussion and to Mr. Edgar R. Fisher for his fine photography.

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[3] The following publication, possibly containing material of significance in this field, has not been accessible to me prior to the completion of this paper. This is a paper by R. T. Young, "The distribution of the mussel (*Mytilus californianus*) in relation to the salinity of its environment" in Ecology, 22 (4) : 379-386, 1941.

AN APPARATUS FOR COLLECTION OF ECTOPARASITES FROM MAMMALS[1]

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During the past 30 months over 3,500 animals have been collected by this department and their ectoparasites removed. A large portion of the animals collected were California ground squirrels; over 200,000 fleas have been obtained from this host. During late summer and fall, ground squirrels are heavily parasitized by fleas; the following maximum flea counts have been recorded from *Citellus beecheyi* (Richardson) at Loma Linda, California: 979, October 8, 1952; 1,176, August 11, 1953; 1,244, August 12, 1953; 2,475, October 25, 1953.

To successfully conduct certain insecticide studies it was necessary to remove all fleas from heavily parasitized animals. Several methods were attempted; the method described below was ultimately adopted.

Essential factors of the apparatus are shown in Figure 1. A standard vacuum cleaner was used as a source of suction. The distal end of the metal attachment tube on the vacuum cleaner was cut off with six inches of the metal tube remaining; see number 5 in Figure 1. A hole $1\frac{1}{4}$ inches in diameter was cut in a Mason jar lid and the metal tube mentioned above was passed through the hole in the jar lid and soldered in place. To prevent the escape of fleas from the jar into the suction tube a fine copper screen, 70 wire strands per inch, was fastened over the end of the metal tube. The copper screen was held in place by a tight fitting section of plastic tubing. The tube through which the fleas passed, number 2 in Figure 1, was constructed from a three-fourth-inch plastic hose, nine feet in length. This hose was held out of the way of the operator by being suspended from a spring attached to an overhead arm; suspending the hose from an overhead spring permitted greater mobility of the nozzle when removing ectoparasites. The hose coupling was screwed to a threaded pipe, the latter was firmly fastened into the jar lid by two large flat nuts on either side of the lid. The collection nozzle is a standard vacuum cleaner accessory which was attached to the three-fourth-inch plastic hose. A one- or two-quart, wide mouth jar may be used as a receptacle for the ectoparasites which are removed from the host by suction. Fleas are readily sucked out of the mammals' fur by moving the tip of the vacuum nozzle through the hair.

[1] This research project was made possible by a contract (DA-49-007-MD-185) from the Research and Development Board, Office of the Surgeon General, Department of the Army. Submitted for publication October, 1953.

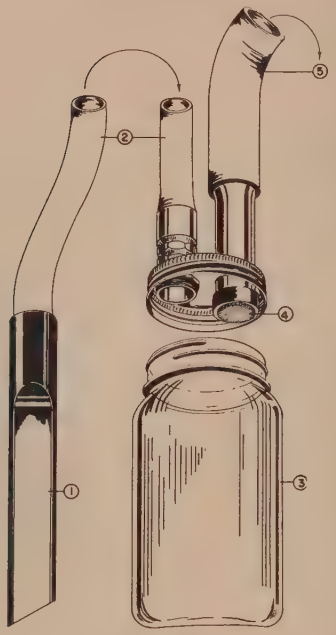

FIGURE 1. Equipment used for collection of ectoparasites from mammals

With the aid of the equipment described above, it was possible to remove 20,000 fleas from 100 California ground squirrels during a period of one week. It was found that most of the fleas were removed by suction, those that remained were collected with forceps. When this technique is used it is recommended that the recently killed mammals be placed in paper bags and their carcasses chilled by placing them in a refrigerator for 12 hours at a temperature of 10 degrees to 15 degrees C. Animals removed from the refrigerator in paper bags should be left at room temperature for one hour to permit the fleas to become active. Contents of a single bag, fleas and dead host are next emptied into an enamel pan of suitable diameter and five inches in depth. The active fleas and other ectoparasites seeking to escape from the dead host can readily be picked up by suction in the enamel pan and the fur of the animal. A limited amount of hair and debris may be sucked into the collection jar with the fleas. This extraneous material can be separated from the fleas by covering the mouth of the jar with a disc of 18 mesh screen held in place by a screw cap band. When the jar equipped as above mentioned is inverted in an enamel pan most of the fleas pass through the screen into the pan; hair and other debris is retained in the jar by the screen.

NOTES

UNDERWATER EXPLOSIONS NOT HARMFUL TO SALMON

During the months of June, July, and August, 1953, submarine geophysical operations were in progress in Central and Northern California waters. This is the first time that seismic explorations have ventured into salmon fishing areas. The major areas of operations were as follows: off Morro Bay, Monterey, Santa Cruz, Halfmoon Bay, Drakes Bay, Point Arena and Eureka, the most northern point being the mouth of the Mad River. Previous to this time, Point Buchon was the northern limit of operations. The majority of work was within one to five miles of shore and in depths ranging from 60 to 300 feet.

The work was carried on in the usual manner as described by Fry and Cox (1953). The explosive used was FFFG black powder. The charge, suspended six feet below the surface, may be either 45 or 90 pounds depending upon the distance from shore. In accordance with the permits issued to the surveying party, a Department of Fish and Game employee, acting as observer, is present at all times during the operations. The author, assigned to the job in this capacity, was approached on several occassions by interested salmon fishermen with two questions predominating: (1) Will the explosions kill salmon? (2) Will the salmon be chased out of the fishing areas by these continuous explosions?

At no time were dead or injured salmon observed. The author noticed many salmon swimming about in the blasting area prior to detonation but none were harmed by the explosions. By trolling with gear similar to that used by commercial salmon trollers, the author and other members of the party were successful in catching 4 king salmon (*Oncorhynchus tshawytscha*) and 11 silver salmon (*O. kisutch*). These fish, ranging from 2 to 30 pounds, were caught within a close proximity of the shot positions during actual shooting operations. One seven-pound silver salmon was caught in the "bubble" approximately 20 seconds after the explosion.

Other species caught included black rockfish (*Sebastodes melanops*), blue rockfish (*S. mystinus*), jacksmelt (*Atherinopsis californiensis*), and jack mackerel (*Trachurus symmetricus*).

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—*Wayne J. Baldwin, Marine Fisheries Branch, California Department of Fish and Game, September, 1953.*

A KELP BASS, *PARALABRAX CLATHRATUS* (GIRARD), WITH ABNORMAL FINS

A kelp bass with unusually long fins (Figure 1) was caught off San Clemente Island from a sportfishing boat about June 15, 1953. These abnormalities left doubt as to the specific identification and the fish was turned over by the Dearden Fish Company, Long Beach, California, to the Department of Fish and Game where the identification was verified.

FIGURE 1. Abnormal specimen collected 15 June 1953

FIGURE 2. Normal kelp bass

The most obvious differences were the lengths of the rays on the soft dorsal fin, anal fin, left ventral fin and caudal fin. The right ventral, both pectorals and the spinous portions of the dorsal and anal fins, however, appeared to be normal. A detailed comparison was made of this fish with 24 normal specimens (Table 1). In addition to the abnormally long fins, several body proportions fell beyond the range of variation shown by the normal sample. The maxillary was longer and the distances from tip of snout to insertions of the anal, pectoral and ventral fins were greater.

The specimen has been deposited in the fish collection at the University of California at Los Angeles.

TABLE 1

Comparison of Various Counts and Body Proportions of Normal and Abnormal Kelp Bass

Standard Length Is Expressed in Millimeters, Other Measurements as Percentage of Standard Length

	Normal (24 specimens)	Abnormal (1 specimen)
Measurements (mean values in parentheses)		
Standard length	173-291 (244.8)	281.0
Total length	121.3-127.8 (125.3)	145.9
Anal fin	14.2-17.6 (16.0)	32.7
Ventral fins, right		20.1
left	19.0-24.3 (21.3)	35.2
Dorsal fin	13.1-16.5 (14.7)	27.2
Pectoral fin	23.7-28.2 (25.9)	26.7
Head length	34.0-39.3 (37.0)	37.4
Fleshy orbit	5.8-7.3 (6.7)	6.8
Maxillary length	13.7-15.8 (15.0)	16.3
Snout length	9.4-12.8 (10.5)	11.4
Suborbital width	2.8-4.3 (3.4)	3.5
Bony interorbital width	6.7-9.1 (7.6)	8.0
Snout to dorsal insertion	36.3-39.9 (37.7)	39.9
Snout to first dorsal ray	59.1-65.5 (62.7)	64.4
Snout to anal insertion	64.3-69.3 (67.2)	70.1
Snout to pectoral insertion	32.6-35.2 (33.8)	37.2
Snout to ventral insertion	35.3-40.6 (37.8)	41.3
Ventral insertion to dorsal insertion	27.8-33.1 (30.0)	30.2
Pectoral insertion to dorsal insertion	18.9-23.1 (20.6)	19.5
Depth at anal insertion	23.4-29.8 (26.1)	26.2
Least depth of caudal peduncle	11.3-12.6 (11.8)	12.0
Counts (number of fish in parentheses)		
Gill rakers, upper limb	11(8); 12(15); 13(1)	12
Gill rakers, middle	1(24)	1
Gill rakers, lower limb	19(6); 20(3); 21(3);	
	22(7); 23(5)	21
Gill teeth, upper limb	7(4); 8(19); 9(1)	9
Gill teeth, lower limb	17(4); 18(8); 19(8);	
	20(3); 21(1)	18
Dorsal spines	X(23); XI(1)	X
Dorsal rays	12(1); 13(18); 14(5)	13
Anal fin	III, 7(23); III, 8(1)	III, 7
Pectoral fin	I, 13(6); I, 14(18)	I, 14
Ventral fin	I, 5(24)	I, 5
Principal caudal rays	9+8(24)	9+8
Pored scales, lateral line (to end of hypural plate)	63(7); 64(6); 65(4);	
	66(4); 67(2); 68(1)	66
Longest rays		
Dorsal	3-5	11
Anal	2-3	5
Pectoral	5-7	10
Ventral	2-3	2
Caudal	2-4 (Dorsal lobe)	3, 4 (Ventral lobe)

—*John L. Baxter, Marine Fisheries Branch, California Department of Fish and Game, September, 1953*

RETIREMENT

EDWARD CLESSEN

Among the more than 800 employees of the Department of Fish and Game no group has a more important role to play year in and year out than the foremen in charge of the State's fish hatcheries. With the closing of the Brookdale Hatchery the Department of Fish and Game lost the services of its oldest foreman in years of state service in tthe retirement of Edward Clessen on November 1, 1953.

Eddie first started work at the old Sisson Hatchery, Mt. Shasta, in March, 1904, at the age of 17 and worked intermittently to 1911. Since then, with the exception of military leave during World War I from November, 1917, to March, 1919, he has worked continuously for a total of 47½ years with the Department of Fish and Game.

During his early years of employment, he assisted with the construction of the fish racks and spawning facilities at Fall Creek. He assisted the late George Neale in the first fish rescue operations in California and over 40 years ago was briefly assigned to the Brookdale Hatchery, from which place he retired. His early assignments included the transfer of catfish from the Sacramento River to Clear Lake and seasonal work on the old railroad fish distribution cars. In 1920, he was temporarily placed in charge of operations at the Kaweah Hatchery, Tulare County. When a permanent hatchery was built at this location in 1928 he was promoted to foreman. In 1934 he was transferred to the Fort Seward Hatchery, Humboldt County, and when this station was abandoned in 1942 he was placed in charge of the Brookdale Hatchery.

Eddie plans to spend his retirement in the vicinity of Brookdale. His host of friends and co-workers extend their best wishes for an enjoyable retirement.—*Earl Leitritz, Supervisor of Fish Hatcheries.*

REVIEWS

How to Fish the Pacific Coast

By Raymond Cannon; Lane Publishing Co., Menlo Park, Calif., 1953; xi + 337 p., 203 figs. $4.

It is not often that a book lives up to the publisher's words of praise on the jacket but Mr. Cannon's manual does just that. The description reads aptly, "How to catch every Pacific Coast game fish—complete angling techniques for boat, surf, rock, breakwater, pier and dock."

Six years of preparation went into this book, preceded by many years of fishing along the coast. The result is one of the best "how to fish" texts to appear in print. At last Pacific Coast fishing has a manual on a par with the better trout and black bass handbooks.

Of real value is the introductory section, "Fishermen's Province." Here is a readable description of the area encompassed—Vancouver, British Columbia to San Quintin, Baja California, as described by one who not only knows the coast but loves it. Following this is an account of fisheries conservation written in fishermen's language. The excellent treatment given this complex subject is recommended reading for all fishermen, sport or commercial. The ideas expressed are the author's own, but the scope of this chapter reflects his close association with the leading research and conservation workers of the Pacific Coast.

Fishing methods are described in two ways—the general type of fishing such as piers, surf, party boats, etc., and by species of fish. Perhaps the best feature of the book is the inclusion of all types of fish and fishing. Everything from catching grunion on the beaches by hand to the mighty swordfish is given equal treatment. Too often angling books are confined to the most refined—and expensive—kinds of fishing with the driest of flies and the driest of prose. Cannon, however, speaks in everyday terms of everyman's angling.

The reviewer in searching for omissions can find but the slightest of faults. The cursory treatment given to "jig" fishing with the heavy silver lures so popular from Port San Luis north was compensated for by the detailed description of the increasingly used stripbait technique.

The section on fish identification is well done. In his laudable effort to standardize the confusion of fish names along the coast, the author consulted with numerous fishermen, ichthyologists and fisheries workers to produce a useful list that should go a long way to solve the problem.

I have no hesitation in recommending Mr. Cannon's handbook to all fishermen, experienced or beginners.—*Seth Gordon, Director, California Department of Fish and Game.*

Methods and Principles of Systematic Zoology

By Ernst Mayr, E. Gorton Linsley and Robert L. Usinger; McGraw-Hill Book Company Inc., New York, 1953; ix + 328 p., 45 figs. $6.

Nomenclature and systematics in zoology (and botany) have long been scorned or held in awe by the average worker in the field of natural sciences. Most of this results from lack of understanding of the subject rather than lack of interest in it. To alleviate this situation there has long been a need for such a work as this present volume. The general format and skill of organization shows careful planning and preparation on the part of the three capable authors. Some of the concepts set forth here will undoubtedly be looked upon with a jaundiced eye but these sections are completely overshadowed by the over-all fundamentally sound reasoning and practical advice.

Generally speaking the style and construction is such as to make reading almost as interesting, definitely as intriguing, and far more informative than a good historical novel. It should be required reading for college zoology teachers, their students and the novices and old-timers in the field who are now practicing biologists.

The book is divided into three major sections: taxonomic categories and concepts, taxonomic procedure and zoological nomenclature. The first section treats broadly such subjects as taxonomy, its history and functions; the species and infraspecific categories; and classification and the higher categories. Perhaps the most important and helpful chapter in the entire book is, "Quantitative methods of analysis." The sections covering presentation of findings and preparation of taxonomic papers will be especially helpful to the novice (and some old-timers). An excellent summary of and commentary on the International Rules of Zoological Nomenclature is particularly timely, especially as the subject is now again in a state of flux and there is no up-to-date edition of the rules. A final chapter on ethics in taxonomy should be read and reread several times a year and the philosophy expounded should become an integral part of every workers "bible." A fairly complete bibliography is followed by a glossary and the entire volume is well indexed.—*John E. Fitch, California Department of Fish and Game.*

Culture and Diseases of Game Fishes

By H. S. Davis; University of California Press, Berkeley, 1953; x + 332 p.; 55 figures. $5.

At the 1936 meeting of the American Fisheries Society in Grand Rapids, Dr. J. E. Bost read a short paper entitled "Why is There No Text Book on Fish Culture?" In the discussion which followed, Mr. Elmer Higgins commented at length and among other things he said, "Why there is no textbook on fish culture can be answered briefly by saying there is no one in the United States capable of writing such a book at the present time." This may have been true in 1936, but in the following 16 years many "capable" men emerged and still there was no textbook on fish culture. I believe I can express the thought of most by saying that no one had both the background and the time to write such a book until Dr. Davis produced the work under review. Previously he had published two editions of "Care and diseases of trout," the last having appeared in 1946. Briefly, the present book is a revision of this earlier paper with some short additional sections on the propagation of salmon, grayling, pikeperch, pike, muskellunge, black bass and other centrarchids, channel catfish, minnows, and suckers.

Since this book has been so long in the making and so eagerly awaited, a few remarks should be made concerning the degree to which it fills the need of all its potential readers. There are three large groups of interested people: the college students taking courses in wildlife management, the fish culturists employed by governmental agencies, and the commercial fish culturists. It is not likely that any one book will ever be written which will fill the needs of all these groups. Surely the present book does not do so. However, of the three groups which I have mentioned it seems probable that this book comes closest to meeting the requirements of the college students. There is no reason why it should not be required reading for all college students of practical fish management. I presume that every college offering courses in this field will have several copies in its library.

This book is essentially an introduction to the field, not a source of basic material. It is a guide to further reading. The author cites abundant references throughout, and the bibliography contains 338 titles. Since most of these papers are cited and since the book itself contains only 307 pages of text it is needless to say that the literature has been lightly touched. The serious student will find a great many things which have not been included; it is a tremendous field and to give thorough treatment to all important phases would require several times this many pages. I feel that several matters have been dealt with to an extent out of proportion to their real value while other subjects have not been included at all. It seems to me that this is the first edition of a book which should go through many editions, each new one being a step toward the "complete" source book which is badly needed.

As long as the book is essentially an introduction to the field, it is in order for it to contain sections on the culture of fishes other than the salmonids but if it is to be revised, as it should be, I cannot see how it can continue to treat the culture of the so-called "warmwater fishes." These fishes and their culture should be treated in a separate book.

Although Dr. Davis is as widely experienced in the field as anyone in the United States, he does not bring himself into the book with objectionable frequency. The exchange of opinion on bacterial gill disease enlivens a subject which, to all but the specialist, must seem dull. There is a minimum of technical terms except where they are absolutely necessary.

Chapters 5, 9, 10, 11 and 12 have no illustrations whatsoever and this seems unfortunate; the value and the interest of the book could be greatly increased by the inclusion of many more good illustrations. Some of the drawings made specifically for it, for example, those on page 44, are rather sorrowful, but most of the others are excellent and the author and the publisher should be complimented. The whole printing job is "modern" and pleasing.

A large part of the book (116 pages) is devoted to diseases. Some will feel that this is out of proportion to the subject's real importance. Perhaps the descriptions of the diseases and their treatment could have been handled a little more concisely, thus giving space for the many diseases which were not mentioned at all. From the standpoint of the beginner, this subject may have been treated as thoroughly as need be, but here again the specialist will be troubled by the omission of many diseases, some quite important.

The presentation of more technical subjects in the appendices is an excellent idea and should be expanded in the next edition. It might not be out of order to include descriptions and sketches of fish-planting equipment, particularly the pickup truck with tank and aeration equipment and the airplane and its equipment for transportation and planting. Some of the more recent developments in the feeding of salmonids might be included in the appendix, and sketches of the various types of trout sorting devices could be added.

Despite the fact that this book will not please everyone, the author nevertheless has written the first book on American game fish culture and he has done a good job.—*Joseph H. Wales, California Department of Fish and Game.*

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